U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: **SYSTEMS AND EQUIPMENT GUIDE FOR CERTIFICATION OF PART 23 AIRPLANES**

Date: 4/25/00
Initiated By: ACE-100

AC No: 23-17
Change:

1. **PURPOSE.** This advisory circular (AC) sets forth an acceptable means, but not the only means, of showing compliance with Title 14 Code of Federal Regulations (14 CFR) Part 23 for the certification of systems and equipment in normal, utility, acrobatic, and commuter category airplanes. This AC applies to Subpart D from § 23.671 and Subpart F. This AC consolidates existing policy documents, and certain AC's that cover specific paragraphs of the regulations, into a single document. Material in this AC is neither mandatory nor regulatory in nature and does not constitute a regulation.

2. **CANCELLATION.** The following AC’s are canceled:

   a. AC 23.679-1, Control System Locks.

   b. AC 23.683-1, Control System Operations Test.

   c. AC 23.701-1, Flap Interconnections in Part 23 Airplanes.

   d. AC 23.729-1, Landing Gear Doors and Retraction Mechanism.

   e. AC 23.733-1, Tundra Tires.

   f. AC 23.807-2, Doors Between Pilot’s Compartment and Passenger Cabin in Small Airplanes.

g. AC 23.807-3, Emergency Exits Openable from Outside for Small Airplanes.

h. AC 23.841-1, Cabin Pressurization in Small Airplanes.

i. AC 23.1305-1, Installation of Fuel Flowmeters in Small Airplanes with Continuous-Flow, Fuel-Injection, Reciprocating Engines.

j. AC 23.1329-2, Automatic Pilot System Installation in Part 23 Airplanes.

3. BACKGROUND. In 1968, the Federal Aviation Administration (FAA) instituted an extensive review of the airworthiness standards of Part 23. Since then, the regulations have been amended through Amendment 23-52. These amendments have changed most of the sections of Part 23. This document is intended to provide guidance for the original issue of Part 23 and the various amendments. This version of the advisory circular covers policy available through June 30, 1994. Policy that became available after June 30, 1994, will be covered in future amendments to the advisory circular.

4. APPLICABILITY. This AC is applicable only to the original applicant seeking issuance of a Type Certificate (TC), an Amended TC, or a Supplemental Type Certificate (STC) for the initial approval of the new type design or a change in the approved type design. This material is not to be construed as having any legal status and should be treated accordingly. This version of the advisory circular covers policy available through June 30, 1994. Policy that became available after that date will be covered in future amendments to the advisory circular.

5. PARAGRAPHS KEYED TO PART 23. Each paragraph has the applicable Part 23 amendment shown in the title. As Part 23 changes occur, the appropriate revisions will be made to the affected paragraphs of this AC.

6. RELATED PUBLICATIONS. These documents are provided as a quick reference source of documents that are acceptable for use in 14 CFR, Part 23 certification programs/projects.

a. Free Orders and AC's

Copies of current publications of the following free Orders and AC's listed below can be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785:

FAA Order 8110.4A, Type Certification Process.

FAA Order 8100.5, Aircraft Certification Directorate Procedures.

AC 20-30B, Aircraft Position Light and Anticollision Light Installation.

AC 20-36S, Index of Articles Certified Under the Technical Standard Order System.

AC 20-41A**,** Substitute Technical Standard Order (TSO) Aircraft Equipment.

AC 20-42C, Hand Fire Extinguishers for Use in Aircraft.

AC 20-67B, Airborne VHF Communications Equipment Installations.

AC 20-74, Aircraft Position and Anticollision Light Measurements.

AC 20-112, Airworthiness and Operational Approval of Airborne Systems to be Used in Lieu of a Ground Proximity Warning System (GPWS).

AC 20-115B, Radio Technical Commission for Aeronautics, Inc., Document RTCA/DO-178B.

AC 20-118A, Emergency Evacuation Demonstration.

AC 20-121A, Airworthiness Approval of Airborne Loran-C Navigation Systems for Use in the U.S. National Airspace System (NAS).

AC 20-124, Water Ingestion Testing for Turbine Powered Airplanes.

AC 20-TCAS (Draft), Airworthiness Approval and Operational Use of Traffic Alert and Collision Avoidance System (TCAS I).

AC 20-128A, Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure.

AC 20-131A, Airworthiness and Operational Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders.

AC 20-136, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning.

AC 20-138, Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Supplemental Navigation System.

AC 21-16D, Radio Technical Commission for Aeronautics (RTCA) Document DO-160D.

AC 21-25A, Approval of Modified Seats and Berths Initially Approved Under a Technical Standard Order.

AC 21-34, Shoulder Harness-Safety Installations.

AC 23-2, Flammability Tests.

AC 23.562-1, Dynamic Testing of Part 23 Airplane Seat/Restraint Systems and Occupant Protection.

AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes.

AC 23.1311-1A, Installation of Electronic Display Instrument Systems in Part 23 Airplanes.

AC 23.1419-2A, Certification of Part 23 Airplanes for Flight in Icing Conditions.

AC 23-xx-28, Airframe Guide for Certification of Part 23 Airplanes.

AC 25-11, Transport Category Airplane Electronic Display Systems.

AC 90-79, Recommended Practices and Procedures for the Use of Electronic Long-Range Navigation.

AC 120-31A, Operational and Airworthiness Approval of Airborne Omega Radio Navigation Systems as a Means of Updating Self-Contained Navigation Systems.

AC 120-37, Operational and Airworthiness Approval of Airborne Omega Radio Navigation Systems as a Sole Means of Long-Range Navigation Outside the United States.

AC 121-13, and Change 1 and 2, Self-Contained Navigation Systems (Long Range).

Copies of current publications of the following “for sale” AC’s may be purchased from the Superintendent of Documents, P. O. Box 371954, Pittsburgh, PA 15250-7954; make check or money order payable to the Superintendent of Documents:

AC 20-88A, Guidelines on the Marking of Aircraft Powerplant Instruments (Displays).

AC 20-101C, Airworthiness Approval of Omega/VLF Navigation Systems for Use in the United States NAS and Alaska.

AC 21.303-2H, Announcement of Availability: Parts Manufacturer Approvals—1992 (Microfiche).

AC 23-16, Powerplant Guide for Certification of Part 23 Airplanes.

AC 23-8A and Change 1, Flight Test Guide for Certification of Part 23 Airplanes.

AC 43.13-1B, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair.

AC 43.13-2A and Change 2, Acceptable Methods, Techniques, and Practices—Aircraft Alterations (includes Change 1).

NOTE: Republishing these AC documents as a part of this AC was not considered to be the best utilization of FAA resources.

b. Industry Documents

(1) To obtain a copy of the Technical Standard Orders (TSO's) listed below, write to the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785:

TSO-C9c, Automatic Pilots.

TSO-C62d, Aircraft Tires.

TSO-C22g, Safety Belts.

TSO-C26c, Aircraft Wheels and Wheel-Brakes Assemblies, with Addendum I.

TSO-C39b, Aircraft Seats and Berths.

TSO-C55, Fuel and Oil Quantity Instruments (For Reciprocating Engine Aircraft).

TSO-C114, Torso Restraint Systems.

(2) The RTCA documents listed below are available from RTCA, Inc., Suite 1020, 1140 Connecticut Avenue, NW, Washington, DC 20036-4001:

RTCA/DO-160D, Environmental Test Conditions and Test Procedures for Airborne Equipment.

RTCA/DO-178B, Software Considerations in Airborne Systems and Equipment Certification.

(3) SAE stands for Society of Automotive Engineers. The SAE documents listed below are available from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001:

ARP 597C, Wheels and Brakes, Supplementary Criteria Design for Endurance—Civil Transport Aircraft.

ARP 813A, Maintainability Recommendations for Aircraft Wheels and Brakes.

ARP 1619A, Replacement and Modified Brakes and Wheels.

AIR 1064B, Brake Dynamics.

AS 1145A, Aircraft Brake Temperature Monitor System.

SAE J384, Motor Vehicle Seat Belt Anchorage's Test Procedure.

SAE Recommended Practice, 1979 SAE Handbook, Volume 2, pages 33.08-33.09.

(4) The Underwriter's Laboratories (UL), Inc., document listed below can be obtained from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112:

UL 1418, Implosion Protected Cathode Ray Tubes for Television Type Appliances, Revised 1992.

S/

Michael K. Dahl
Acting Manager, Small Airplane Directorate
Aircraft Certification Service

CONTENTS

Subpart D—Design and Construction

CONTROL SYSTEMS

LANDING GEAR

FLOATS AND HULLS

PERSONNEL AND CARGO ACCOMMODATIONS

PRESSURIZATION

FIRE PROTECTION

ELECTRICAL BONDING AND LIGHTNING PROTECTION

MISCELLANEOUS

Subpart F—Equipment

GENERAL

INSTRUMENTS: INSTALLATION

ELECTRICAL SYSTEMS AND EQUIPMENT

LIGHTS

SAFETY EQUIPMENT

MISCELLANEOUS EQUIPMENT

SYSTEMS AND EQUIPMENT GUIDE FOR CERTIFICATION OF PART 23 AIRPLANES

Subpart D—Design and Construction

CONTROL SYSTEMS

23.671 General

No policy available as of June 30, 1994.

23.672 Stability augmentation and automatic and power-operated systems

Amendment 23-45 and Subsequent

This rule is applicable **only** if the system is required to show compliance with the flight characteristic requirements of Part 23.

23.673 Primary flight controls

No policy available as of June 30, 1994.

23.675 Stops

No policy available as of June 30, 1994.

23.677 Trim systems

Original Issue and Subsequent

The trim system should prevent inadvertent, improper or abrupt trim operation. The direction of trim movement and its relation to its range of adjustment should be designed to prevent confusion.

Trim devices should be designed to continue normal operation with one failure of any connecting or transmitting element in the primary flight control system for (1) longitudinal trim in a single-engine airplane, and (2) longitudinal and directional trim in multiengine airplanes.

Amendment 23-7 and Subsequent

The amendment requires there be adequate control for safe flight and landing (rather than to "continue normal operation") using the trim devices following the failure of a connecting/transmitting element in the primary controls. Thus, the control system element failure must not cause a failure of the trim system.

Failures of the trim system must not prevent safe flight and landing.

Amendment 23-34 and Subsequent

Probable powered trim runaways should be demonstrated for all Part 23 airplanes so equipped. See AC 23-8A, Change 1, Flight Test Guide for Certification of Part 23 Airplanes, for the procedure.

Even if trim runaways have been determined to be improbable using the guidance in AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes, appropriate trim runaway demonstrations in all axes are required to demonstrate that the airplane has no unsafe features. The FAA has accepted demonstration of control restrained trim runaways during malfunction testing for systems without a monitor/limiter regardless of the reliability and those with a monitor/limiter whose reliability is less than extremely improbable. However, the FAA has determined this procedure is not acceptable in itself for failure conditions shown to be less than extremely improbable. In order to allow expansion of the 0 to 2g envelope, as specified in AC 23-8A, the FAA suggests a test procedure that incorporates both control restrained and unrestrained malfunctions. The following test matrix considers the probability of trim runaways, high airframe limit loads, control stick/wheel configuration and absence of an autopilot system. Because rudder trim can be adjusted without the pilot directly in the control loop (i.e., feet on the floor), restrained runaways for rudder trim are not considered acceptable. (See Table 1 in this section.)

TABLE 1. TRIM SYSTEMS REQUIREMENTS

Axis	Time	Load(g) (unrestrained)	Maximum Attitude Change (unrestrained)	Maximum Force (restrained and unrestrained)	Maximum Rate of Force Change (restrained)
Pitch	recognition +3 seconds	structural limits NTE 3.5g	+/-45 degrees	60 pounds	20 pounds/sec
roll	recognition +3 seconds	structural limits	+/-90 degrees	30 pounds	10 pounds/sec
yaw	recognition +3 seconds	structural limits	+/-30 degrees	150 pounds (unrestrained only)	N/A

Note 1: Restrained means the pilot is in the control loop (hands on) and unrestrained means the pilot is not in the control loop (hands off).

Note 2: Trim systems with a monitor/limiter will be tested at a magnitude just below that required for monitor/limiter trip.

Note 3: NTE is Not to Exceed.

23.679 Control system locks

Original Issue and Subsequent

Section 23.679(a) of Part 23 and § 3.341(a) of the CAR require that if there is a device to lock the control system, there should be a means to give unmistakable warning to the pilot when the lock is engaged. Several accidents have occurred because the pilot did not remove the control system lock prior to takeoff. Many such accidents relate to internally applied locks, mostly pins installed at the control wheel column. Misuse and alteration of these installed locking devices, together with neglect by the pilot to perform a control freedom check before takeoff, contributed to such accidents.

When evaluating a control lock system, the following factors should be considered in finding compliance with the applicable regulation:

a. The warning should be easily observable during both day and night operations. Color, location, shape, and accessibility of the device, ease of removal with the pilot seated in the flying position, and legibility of any placards, etc., should be considered.

b. The system operation should be obvious. It should be possible to apply the lock only in such a manner that the required warning is provided.

c. When engaged, the lock should, by design, limit the operation of the airplane so that the pilot receives unmistakable warning in the cockpit before or at the start of takeoff by an effective means, such as one of the following:

(1) Preventing the application of sufficient engine power to attempt a takeoff.

(2) Displacement of primary pilot controls, such as the control wheel full forward.

(3) An aural warning device that cannot be disengaged.

For airplanes with separate locks for throttle and control column, where one lock (e.g., throttle) can be removed independently of the other, each lock should independently meet the criteria of paragraph (c) above.

23.681 Limit load static tests

No policy available as of June 30, 1994.

23.683 Operation tests

Original Issue and Subsequent

The 1.25 factor of Part 23, § 23.395(a)(1) does not apply to the control system operational test of this section.

Compliance with this section is required whether or not the airplane has a significant flight test history. Proof of structure is accomplished by ground tests because required flight tests may not subject the airplane to limit loads for all possible flight conditions.

Amendment 23-7 and Subsequent

Part 23, § 23.683, and CAR Section 3.343 require showing by operation tests, when the controls are operated from the pilot compartment with the system loaded, that the system is free from jamming, excessive friction, and excessive deflection. This section has not been uniformly applied. Some airplanes were certified using 50 percent of the control surface travel with no load as criteria for meeting the excessive deflection requirements for the operation tests. Other airplanes were not required to meet any specific travel as long as the airplane had adequate flight characteristics.

Requiring a specific large travel while under limit load could result in control system authority that is greater than desired or needed. However, some travel of the control surface should exist when the system is loaded to limit load. No travel could indicate there was a possible fault, such as a jammed system. Secondly, with little or no travel, operation of the controls would have such a limited effect on the maneuverability of the airplane that it could have questionable flight characteristics.

Compliance with § 23.305 must also be demonstrated. Contact the Small Airplane Directorate for § 23.305 guidance.

ACCEPTABLE MEANS OF COMPLIANCE

One method, but not the only method, for showing compliance with the control system operation test requirements of § 23.683 and CAR Section 3.343 is as follows:

a. Conduct the control system operation tests by operating the controls from the pilot's compartment with the entire system loaded so as to correspond to the limit control forces established by the regulations for the control system being tested. The following conditions should be met:

(1) Under limit load, check each control surface for travel and detail parts for deflection. This may be accomplished as follows:

(a) Support the control surface being tested while positioned at the neutral position.

(b) Load the surface using loads corresponding to the limit control forces established in the regulations.

(c) Load the pilot's control until the control surface is just off the support.

(d) Determine the available travel, which is the amount of movement of the surface from neutral when the control is moved to the system stop.

(e) The above procedure should be repeated in the opposite direction.

(f) Minimum control surface travel from the neutral position in each direction being measured should be 10 percent of the control surface travel with no load on the surface.

Regardless of the amount of travel of the surface when under limit load, the airplane should have adequate flight characteristics, as specified in § 23.141. Any derivative airplane of a previous type certificated airplane need not exceed the control surface travel of the original airplane; however, the flight characteristics should be flight tested to ensure compliance.

(2) Under limit load, no signs of jamming or of any permanent set of any connection, bracket, attachment, etc., may be present.

(3) Friction should be minimized so that the limit control forces and torques specified by the regulations may be met.

23.685 Control system details

No policy available as of June 30, 1994.

23.687 Spring devices

No policy available as of June 30, 1994.

23.689 Cable systems

Original Issue and Subsequent

If tabs are installed with cable less than 1/8th inch diameter, the airplane should be safely controllable with the tabs in the most adverse position as if from a failed cable. Using emergency procedures, the pilot should be able to return and land safely. Airplane configurations, such as flaps, landing gear, and power are permissible devices to use in relieving control forces. The temporary control forces of Part 23, § 23.143, are applicable until the force reduction procedures are completed.

23.691 Artificial stall barrier system

Amendment 23-49 and Subsequent

Section 23.201(b), Amendment 23-45, added the activation of an artificial stall barrier as an acceptable means of identifying when a stall has occurred. A stall barrier is a device that prevents an actual stall (i.e., a stick pusher) while a stall warning is a device that alerts a pilot of an impending stall (i.e., a stick shaker). Of course, the actual stall should not occur before activation of the stall barrier. This amendment provided the standards for an artificial stall barrier system **when** it is used to show compliance with § 23.201(b).

A stick pusher system would be a critical system for an airplane with stall recovery that is undetermined, marginal, or unacceptable. Failure of the system is then required to be extremely improbable. The FAA does not consider the probability of entering a stall environment as a factor in developing system reliability. The exception would be developing specific system component reliability where that component would be active only when the airplane is in a stall environment. The FAA does not give credit toward developing reliability for the use of a 'Go/No Go' preflight system check, although the FAA does recommend that preflight procedures for all essential/critical systems be provided for pilot use. (Service experience has shown that some Part 23 airplane pilots do not have the discipline to conduct the prescribed preflight checks.) The development of normal/abnormal/emergency procedures is not a factor in determining system reliability; however, such procedures are desirable, as well as required by § 23.1581. These factors may be considered when exercising engineering judgment in approval of the overall system.

Stall may be identified by stick shaker/pusher operation, uncontrollable downward pitching, or the elevator control reaching the stop (see AC 23-8A)—whichever occurs first in any particular flight regime is acceptable. An airplane may be approved if it has stick shaker/pusher operation in one configuration, such as power on, and it has acceptable stall characteristics for the remaining configurations.

Inadvertent stick pusher operation should be investigated and shown not to be hazardous and to be recoverable, or that inadvertent operation is extremely improbable.

23.693 Joints

No policy available as of June 30, 1994.

23.697 Wing flap controls

No policy available as of June 30, 1994.

23.699 Wing flap position indicator

No policy available as of June 30, 1994.

23.701 Flap interconnection

Original Issue

The flaps should be synchronized by a mechanical interconnection unless the airplane has safe flight characteristics with the flaps retracted on one side and fully extended on the other side. The safe flight demonstration with asymmetry should be shown throughout the airspeed range permitted for flap extension. The control forces should not exceed those shown for temporary application in the table in § 23.143(c). However, they may not exceed the force that can be demonstrated as safe with one hand on the control wheel/stick (other hand needed to re-trim, pull circuit breaker, operate flap control, etc.). If the forces of asymmetry cannot be alleviated in a reasonable period of time, the remaining forces should not exceed those specified for prolonged application in § 23.143(c).

After demonstrating that the airplane has safe flight characteristics with the flaps in their most adverse position, it is permissible to readjust the remaining flap surfaces after a malfunction occurs.

Amendment 23-42

Amendment 23-42 was not intended to change the requirement that "The main wing flaps and related movable surfaces as a system must be synchronized by mechanical connection. . . ." The main purpose of this change was to add the following requirement that would maintain synchronization so that the occurrence of an unsafe condition has been shown to be extremely improbable. This requirement includes provisions for synchronization of the flaps other than by mechanical interconnection of the flap. These reliability requirements by numerical probability analysis for other synchronization methods should not be applied to mechanical interconnection.

It is difficult to assess the reliability of mechanical interconnections by examples of different types of mechanisms. The complete system needs to be analyzed and tested.

Section 23.701, as amended by Amendment 23-42, in part, states the following:

(a) The main wing flaps and related movable surfaces as a system must:

> **(1)** Be synchronized by mechanical connection; or
>
> **(2)** Maintain synchronization so the occurrence of an unsafe condition has been shown to be extremely improbable; or

(b) The airplane should be shown to have safe flight characteristics with any combination of extreme positions of individual movable surfaces (mechanically interconnected surfaces are to be considered as a single surface).

During a recent review of this new requirement, it was noted that the new § 23.701(b), particularly the parenthetical portion of that paragraph, could be improperly interpreted and applied. It is possible that this misinterpretation could result in the use of differing terminology (i.e., "mechanical interconnection" and "mechanically interconnected") in paragraphs (a)(1) and (b). These terms mean the same thing; direct positive mechanical interconnection between separate flap surfaces that are isolated from the flap control or actuation system.

An example where this improper interpretation could occur would be during the evaluation of a flap system, which consists of a central gearbox that turns two or more flexible shafts that, in turn, drive independent jackscrews located at each flap section. Because the flexible shafts in this type of system are mechanical, it could be argued that the individual flap surfaces are "mechanically interconnected;" therefore, under the parenthetical statement in § 23.701(b), it could be considered a single surface. This is not a correct assumption. The term “interconnected" was intended to define a separate positive connection, which is not part of the flap actuation system.

Service history of flap systems with a complex means to position individual flap surfaces, such as the example above, shows that failures can and do occur when one surface is driven to one extreme position while the opposite surface(s) is left in the reverse extreme position. These systems should provide a simple and positive mechanical interconnection between the flap surfaces or should perform a flight test over the speed range where a failure may occur (for both commanded and uncommanded flap positions). This would demonstrate that the airplane flies safely with the most adverse asymmetrical flap positions possible. In flap systems that include leading edge flap surfaces, fore and aft asymmetry as well as left and right asymmetry should be considered.

In summary, the intent of this rule is to address a possible jam or failure of the flap control system. A failure could result in an asymmetric flap condition, unless there is a separate mechanical interconnection between the flaps. The alternative to providing the separate interconnection in the flap system design is showing that the airplane has safe flight characteristics with any flap asymmetry that may occur in service.

Novel and unusual design features, such as an interconnection of the leading and trailing edge flap systems or an interconnection of flaps and ailerons, would require special conditions.

Equivalent Level of Safety Findings

Several findings have been accepted for the mechanical interconnection requirement.

a. Synchronized by a Mechanical Interconnection

These words appeared in 14 CFR Parts 23 and 25 and in CAR 03 and 04b since they were first issued. The synchronization requirement for the motion of the flaps by a mechanical interconnection is applicable to airplanes not having safe flight characteristics under asymmetrical flap operations. For these cases, there would be a hazardous condition when the flaps are retracted on one side and extended on the other side.

b. Mechanical Interconnection Requirement of § 23.70l(a)(l)

This requirement is to ensure against hazardous asymmetrical operation of the flaps after any probable single or probable combination of failures of the flap actuating system. A probable combination of failures should be considered when the first failure would not be detected during normal operation of the system, including periodic checks, or when the first failure would inevitably lead to other failures. (Systems where a probable combination of failures may occur include the electrical and hydraulic systems.) The airplane also should be shown to be capable of continued safe flight and landing without requiring exceptional pilot skill or strength following these failures. To demonstrate that the airplane is safe under these conditions, tests should be conducted with the flaps being retracted on one side and extended on the other during takeoffs, approaches, and landing. If there is a probable hazardous condition, a separate positive connection that is not part of the flap actuation system is required.

ACCEPTABLE MEANS OF COMPLIANCE

An acceptable means of compliance with the airworthiness requirements for the flap's mechanical interconnections of § 23.701(a)(1) are described below:

a. Reliability

Reliability of the mechanical interconnections is generally shown either by load analysis or load tests, or both, not by numerical probabilistic analysis. The mechanical interconnection should be designed for the loads resulting when interconnected flap surfaces on one side of the plane of symmetry are jammed and immovable, while the surfaces on the other side are free to move and the full power of the surface actuating system is applied. It should also be designed to account for the asymmetrical loads resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at takeoff power. For single engine airplanes and multiengine airplanes with no slipstream effects on the flaps, it may be assumed that 100 percent of the critical air loads acts on one side and 70 percent on the other. The flight loads from § 23.345 acting on the surfaces should be considered in combination with the actuating system loads (including system inertia loads). Critical air load conditions should consider flap retraction and flap extension, including go-around. These conditions are considered limit loads. If there are no hazardous conditions when the flaps are asymmetrical, the jam or maximum load conditions could be considered an ultimate load.

b. Friction Loads

It may be necessary to consider friction loads in the actuating system that may be reasonably expected to occur in service. Each design should be evaluated to determine its susceptibility to friction in the mechanism and any loads with such resistance.

c. Equivalent Means by Use of the Mechanical Actuation System

The mechanical actuating system for the flaps may be considered the mechanical interconnection, if all elements are mechanically interconnected from the actuator source to the flaps. These mechanical elements may include structures, interconnection linkages, and drive system components. When the mechanical interconnection is through the actuating system, and it is the only means to prevent an unsafe asymmetrical condition, the loads associated with the jam conditions are considered limit loads. A 1.5 factor of safety is required if a failure as a result of the jam condition would cause a hazardous flap asymmetrical operation. A mechanical actuating system having a 1.5 factor of safety may not need to be evaluated for probable failure conditions. Also, if the drive system is designed so that a hazardous flap asymmetrical operation would not occur after a jam condition, the 1.5 factor of safety should not be required.

d. Equivalent Means by Use of a Warning and Prevention System

A second equivalent means is the use of a warning and prevention system. This system monitors the symmetrical condition of the flaps and warns the pilot when an unsymmetrical flap condition occurs, but the asymmetry is still kept within safe limits. It prevents further movement of the flaps from exceeding safe limits. The warning and prevention system should be independent for each functionally related set of surfaces (i.e., a set of flaps on each side of a plane of symmetry that is driven by a common actuator). Again, the airplane should be shown to have safe flight characteristics without requiring exceptional piloting skill or strength at the extreme limits of the asymmetrical condition where the flaps are stopped. Tests should be conducted to simulate flap malfunctioning at the most severe case in the static asymmetrical condition of the flaps during takeoffs, approaches, and landings. The warning and prevention system should provide a pilot with a selectable or automatic test mode that exercises the system to an appropriate depth, so the pilot can determine proper operation of this system.

e. Electrical/Electronic Flap Interconnection System

When Amendment 23-42 was adopted, § 23.701 was amended to include provisions for airplanes with a flap configuration other than a mechanical interconnection. This amendment added the following requirement in § 23.701(a)(2): "Maintain synchronization so that the occurrence of an unsafe condition has been shown to be extremely improbable." This requirement is applicable for electrical/electronic flap interconnection systems, such as airplanes that have additional flaps and tandem wings. Guidelines for performing a design safety assessment by application of § 23.1309(b), as adopted by Amendment 23-41, are given in AC 23.1309-lC. This AC also provides guidance regarding design safety assessments, environmental and atmospheric conditions, and software assessment.

23.703 Takeoff warning system

No policy available as of June 30, 1994.

LANDING GEAR

23.721 General

No policy available as of June 30, 1994.

23.723 Shock absorption tests

Original Issue

This regulation **requires** shock absorption tests be performed for certification.

Amendment 23-23 and Subsequent

This amendment permits an analysis rather than a shock absorption test, but to do so the applicant should have a landing gear system with **identical** (similar is not acceptable) energy absorption characteristics. The energy absorption characteristics of the landing gear system (e.g., structure, wheel tire, shock absorber) should be included in determining the dynamic response of the landing gear system. The tests should cover a range of energy absorption characteristics and weights over which the analysis is shown to be valid. If these conditions are not met, drop tests will be required to substantiate maximum takeoff and landing weight increases. It is acceptable to modify individual gear drop test data by adapting the results to the complete aircraft analytically, accounting for the aircraft flexibility.

23.725 Limit drop tests

Original Issue

This rule gives requirements for limit load drop tests if the applicant uses free drop tests to meet the requirements of § 23.723(a). The applicant should make ten drops from limit height for each basic design condition. The applicant should make one drop from the height (maximum is 2.25 times the limit drop height) needed to develop 1.5 times the limit load using the limit drop weight.

Amendment 23-7 and Subsequent

This amendment requires that the limit inertial load factor be determined in a rational and conservative manner during the drop test using a landing gear unit attitude and applied drag loads that represent the landing conditions.

23.726 Ground load dynamic tests

No policy available as of June 30, 1994.

23.727 Reserve energy absorption drop test

Amendment 23-7 and Subsequent

Paragraph (b) in § 23.727 requires that the effect of wing lift be provided for in reserve energy drop tests. You should also use the applicable drag loads, as specified in § 23.725(c).

23.729 Landing gear extension and retraction system

Original Issue

No policy available as of June 30, 1994.

Amendment 23-7 and Subsequent

A warning device with no manual shutoff is required when the flaps are "to or beyond" the approach flap setting if the landing gear is not down and locked. The "to or beyond" phrase in relation to using a normal landing procedure is intended to provide for differences in design, as follows:

a. For airplanes whose normal procedures only prescribe landings with flaps extended past the approach setting, only the "beyond" aspect of this rule is appropriate. Operating information for these airplanes should convey that landings with approach flaps, or less, are not normal and will not activate the flap/landing gear aural warning.

b. For airplanes whose normal procedures include landings with a flap setting at the approach setting, the "to and beyond" aspect of this rule is appropriate. Designers may choose to include additional logic in the flap/landing gear warning system, such as airspeed, thrust/throttle position, etc. This logic may tend to minimize nuisance warnings and may provide the equivalent safety intended by the rule.

Because Part 23 is not specific with regard to flap positions used, we cannot specify the flap position that actuates the warning device. This rule provides a basis for the FAA and the applicant to mutually agree on the set point for the warning device.

Although not defined in Part 23, most airplanes do have a "normal landing procedure" and an "approach flap position." The flap position will vary among models, but it is this position that should be used to show compliance.

This information is applicable to the structural substantiation to the loads resulting only from all yawing conditions for the landing gear doors and retraction mechanism of small airplanes per Part 23, § 23.729(a)(2).

Section 23.729(a)(2) requires the landing gear doors and retraction mechanism to be substantiated for the loads resulting from all yawing conditions. Attempts have been made to meet these requirements by flight testing to dive speed with some yaw or by flight testing at full yaw at a lower speed. These procedures normally do not result in a test that substantiates a 1.5 factor of safety. If substantiation by flight testing is desired, the landing gear doors and retraction mechanism should be subjected to 1.5 times the limit "q" loading. The limit "q" loading is the "q" at V_{LE} or V_{LO}, whichever is greater.

The higher of the above speeds at which V_q is to be computed is designated as V_{LG}.

ACCEPTABLE MEANS OF COMPLIANCE

One method, but not the only method, for showing compliance with the structural requirements of § 23.729(a)(2) for the loads resulting from all yawing conditions for the landing gear doors and retraction mechanism is as follows:

a. Substantiation may be accomplished by flight testing at a speed of V_q and the yaw angle determined in paragraph a(3) below, unless this will exceed the structural limitation as determined by analysis, static test, or a combination of both, where:

(1) V_q = square root of (V_{LG} squared times 1.5).

(2) V_{LG} = The greater of V_{LO} or V_{LE}.

(3) For the yawed condition, the limit "q" load will be at V_{LG} with the airplane at the yaw angle determined by § 23.441. This angle need not exceed 15^o. Substantiation should be to 1.5 "q".

(4) If V_q is equal to or less than V_A, substantiation by flight test may be accomplished.

(5) If V_q is greater than V_A, the yaw necessary to produce 1.5 "q" could result in overloading other airplane structures, and the maneuver should not be performed.

(6) V_{LG} may be reduced by imposing limitations on the airplane such that Vq is less than V_A.

(7) The definitions of the terms used above are equivalent airspeeds, as follows:

V_A = Design maneuvering speed

V_D = Design diving speed

V_{LG} = Landing gear speed used in the calculation of V_q

V_{LE} = Maximum landing gear extended speed

V_{LO} = Maximum landing gear operating speed

V_q = Speed which results in 1.5 times limit "q" loading

b. If the condition of Item a.(5) above exists, substantiation of the landing gear doors and retraction mechanism may be accomplished by static tests, analyses, or a combination of both.

23.731 Wheels

See 23.735, Brakes.

23.733 Tires

Original Issue and Subsequent

The following is a recommended test procedure for the installation of tires on a part 23 airplane:

1. Inflate an inboard main tire to the minimum allowable inflation pressure for the airplane weight.

2. Inflate the outboard main tire on that same landing gear to the maximum allowable inflation pressure for the airplane weight.

3. Using white shoe polish or equivalent, mark a 2 inch wide stripe on the brake (inboard) side of the outboard tire sidewall adjacent to the wheel rim.

4. Conduct at least two maximum effort, non-skidding taxi turns into the minimum inflation side of the airplane.

5. Check for evidence of brake wheel housing abrasion contact on the tire sidewall.

Note: Above applies to a dual tire installation per landing gear. For a single tire per gear, inflate either side to the minimum pressure and the opposite side to maximum, and turn into the minimum pressure side.

Tundra Tires

1. **PURPOSE.** This guidance serves several purposes. First, it summarizes the results of flight tests recommended by the National Transportation Safety Board (NTSB) and conducted by the Federal Aviation Administration (FAA) to investigate the effects of tundra tires installed on a Piper PA-18. Second, it provides information concerning possible hazards associated with the type of operations common for tundra tire users and potential adverse effects of untested installations. Third, it provides general information about the certification process for oversized "tundra" tires, as well as an example "compliance checklist" for the installation of such tires on light airplanes that have Civil Air Regulations (CAR) Part 3 for a certification basis.

2. **RELATED READING MATERIAL**

   a. Part 23, CAR Part 3, and CAR Part 03.

   b. National Transportation Safety Board (NTSB) Safety Recommendation A-95-13, dated February 7, 1995.

c. Technical Standard Order (TSO)-C62d, Aircraft Tires.

d. AC 43.13-1BAC 43.13-1B, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair.

3. BACKGROUND. In Safety Recommendation A-95-13, dated February 7, 1995, the NTSB shared some of their safety concerns about tundra tires with the FAA and requested that the possibility of problems with tundra tires be investigated. The NTSB stated the following:

"Since the early 1960's, hundreds of airplanes operating in Alaska have been equipped with tundra tires, and dozens of versions of tundra tires—some exceeding 35 inches in diameter—have been marketed. The Safety Board is concerned that field approvals and STC's have been granted for use of these tires without flight test or other data on the aerodynamic effects of the tires and wheels. The Piper PA-18 is the airplane most frequently equipped with tundra tires. The Safety Board believes that the FAA should conduct a demonstration flight test to determine the effects of tundra tires on the PA-18's flight characteristics—including cruise, climb, takeoff, and landing performance—and, in both straight and turning flight, stall warning and aircraft stability at or near the critical angle of attack. Further, if the tests of the PA-18 indicate the need, the FAA should take corrective action and expand testing to other airplane types equipped with oversized tires."

4. SUMMARY OF FLIGHT TEST RESULTS FOR PIPER PA-18 EQUIPPED WITH TUNDRA TIRES

The FAA's flight tests of tundra tires and their results are detailed in Appendix 1 following this guidance. As can be seen in the report, the tundra tire installations on the Piper PA-18 "150" caused no observable adverse effects on stall or stall characteristics during the FAA tests. Although there was some degradation of handling qualities associated with increasing the tire size, the effect was not significant with regard to safety. Rate of climb and cruise speed were degraded with the larger tire sizes; however, the aircraft still met certification requirements. Additional tests conducted by an independent Designated Engineering Representative (DER) flight test pilot showed the same lack of effect on stall characteristics with the main landing gear fabric covering removed. It should be remembered that these results are valid **only** for the Piper PA-18 "150" and for tires no larger than those tested. It should also be noted that, although tundra tires did not cause a safety problem, the stall characteristics of the basic Super Cub (and most other airplanes) make low altitude turning stalls hazardous, especially in uncoordinated flight. Also, although washout was not varied during these flight tests, previous FAA experience has shown that stall characteristics are further aggravated when operators of the PA-18 remove the 2.5° of washout at the wing tip, which is not an approved alteration. This condition will result in a rapid roll when the airplane is stalled during turning flight.

5. POTENTIAL ADVERSE EFFECTS OF TUNDRA TIRE INSTALLATIONS ON OTHER AIRPLANES

a. Performance

Tundra tire installations on airplanes other than the Piper PA-18 **may** produce one or more of the following effects on performance characteristics:

(1) Increased stall speed.

(2) Reduced stall warning margin.

(3) Reduced rate of climb.

(4) Reduced maximum angle of climb.

(5) Reduced maximum level flight speed.

(6) Reduced cruise speed.

(7) Reduced range.

Tundra tires reduce climb, cruise, and range performance more when installed on relatively “clean,” well streamlined airplanes than they do when installed on less streamlined airplanes.

b. Flight and Ground Handling Characteristics

Tundra tire installations on airplanes other than the Piper PA-18 **may** produce one or more of the following effects on handling characteristics:

(1) Reduced ability of brakes to hold against takeoff power.

(2) Reduced brake effectiveness during rejected takeoff and braked landing.

(3) Reduced stability and controllability during rejected or balked landing and go around.

(4) Change in either trim range or trim authority, or both.

(5) Reduced directional stability and control during takeoff and landing ground rolls, with consequent increased tendency to ground loop.

(6) Increased tendency to nose over during landing.

(7) Reduced stall warning margin, change in either aerodynamic stall warning characteristics (warning buffet) or reduced effectiveness of stall warning system, or both, in both level and turning flight with power either on or off, or both.

(8) Changes in stalling and stall recovery behavior in both level and turning flight with power either on or off, or both. Stalls may become more abrupt and altitude loss before recovery may increase.

(9) Increased tendency to enter an inadvertent spin and reduced ability to recover from the spin.

(10) Reduced longitudinal**,** lateral, and directional stability.

(11) Increased airframe vibration and buffet.

Tundra tires reduce the airplane's directional stability and controllability during takeoff and landing ground rolls, increase its tendency to ground loop during takeoff and landing ground rolls, and increase its tendency to nose over during landings on paved surfaces more than during landings on gravel, grass, or other surfaces that allow the tires to skid more easily.

6. CERTIFICATION OF TUNDRA TIRES FOR USE ON LIGHT AIRPLANES

The certification process for tundra tires is the same as for any other tire to be used in aviation.

a. A manufacturer may obtain a Technical Standard Order Authorization (TSOA) for the tire using the requirements in TSO-C62d. TSO-C62d contains minimum performance standards for aircraft tires. The TSOA, which covers design and manufacturing of the tire only, is not an installation approval. The tire should be approved for installation on a specific airplane model via Type Certificate (TC) or Supplemental Type Certificate (STC). The applicable requirements for installation of a tire on a given airplane should be determined based upon the original certification basis specified in that airplane's Type Certificate Data Sheet. The development of a compliance checklist, as described in Item 7 below, should be accomplished by the applicant together with the FAA engineer.

b. An alternative certification method exists for a tire that does not have a TSOA. In such a case, the tire design approval may be obtained concurrently with the installation approval for specific airplane models via TC or STC. The requirements of the TSO can be used for a determination of acceptable tire performance in such a project. The applicable requirements for installation of a tire on a given airplane should be determined based upon the original certification basis specified in that airplane's Type Certificate Data Sheet. The development of a compliance checklist, as described in Item 7, should be accomplished by the applicant together with the FAA engineer. Prior to offering tires approved by this method for sale, the tire manufacturer would need a Parts Manufacturing Approval (PMA).

7. COMPLIANCE CHECKLIST

See Appendix 2 for an example of the "Compliance Checklist," to CAR Part 3 as amended to November 1, 1949. This checklist is intended to show all aircraft certification requirements that **could** be affected by a tundra tire installation. Many of these requirements may be unaffected by a given installation. The actual compliance checklist for a specific installation should be determined at the start of a project. (See Appendix 1 and Appendix 2 in this section, which are applicable to § 23.733 Tundra Tires.)

APPENDIX 1

FAA TEST RESULTS/EFFECTS OF TUNDRA TIRES ON THE HANDLING QUALITIES/STALLS/STALL CHARACTERISTICS OF THE PIPER PA-18

1. Tests

Recent accidents in Alaska involving airplanes equipped with tundra tires prompted the National Transportation Safety Board to recommend to the FAA that they conduct flight tests to determine the effects of tundra tires on aircraft performance, stalls, and handling qualities. The following five tires were evaluated at various combinations of center of gravity/weight:

a. Factory installed (8.00-6)

b. McCreary Tundra Tires (8.50-10)

c. McCreary Tundra Tires (29x11.0-10)

d. Schneider Racing Slicks (14.0x32.0x15)

e. Goodyear Airwheels (35x15.0-6)

2. Results

Quantitative/qualitative data obtained from the testing of the four tundra tires were compared to the data obtained from the testing of the factory-installed tire. The following is a summary of the findings:

a. Ground Handling

Forward field of view during taxi is inversely related to tire size. As the tire size increases, the ability to see over the nose decreases requiring that the pilot make "S" turns with the airplane. Ground handling during takeoff from a gravel runway is satisfactory for all configurations. Ground handling during landing on a gravel runway is also satisfactory for all configurations tested, although there is a noticeable nose down pitching moment when the tire(s) contact the ground. This is most evident when making a main wheel only landing. Crosswind landings on runway 13 at Lake Hood Strip, a 2,200′ x 80′ gravel runway next to Lake Hood 3 miles southwest of Anchorage, Alaska, were demonstrated for tire configurations Items 1a, 1b, and 1c in winds from 180° (from ahead and to the right of the airplane at an angle of 50° to its flight path) at 14 knots gusting to 16 knots. The wind thus had a crosswind component of approximately 10.7 knots gusting to approximately 12.3 knots and a head wind component of approximately 9.0 knots gusting to approximately 10.3 knots. No crosswinds were available during tests for configurations d and e. No tests for ground handling were accomplished on paved runways. The ground handling characteristics of airplanes equipped with tundra tires are known to be substantially poorer on pavement than on gravel, grass, and other surfaces that allow the tires to skid easily.

b. Performance

Tundra tires adversely affect airplane performance. For example, the uncorrected average rate of climb (tested at 1.05 times maximum gross weight) for the standard tire was 526 feet per minute. The uncorrected average rate of climb for configurations Items 1d and 1e (tested at 1.05 times maximum gross weight) was 449 and 464 feet per minute, respectively.

3. Stalls/Stall Characteristics

a. The purpose of the stall tests was to determine whether there are any differences between the stalling speed and stall characteristics of a PA-18 ‘150’ airplane equipped with tundra tires and the stalling speed and stall characteristics of the same airplane equipped with standard tires. The data obtained from the stall tests do not validate the theory that tundra tires increase the PA-18 ‘150’ stalling speed.

b. Stall characteristics (all configurations) are normal when the airplane is stalled in balanced flight. In a turning stall, the airplane generally rolls slowly to a near wings level attitude. In maneuvering flight, the tendency is for the nose to drop as the bank angle is increased. If the pilot uses top rudder (right rudder in a left turn) to compensate for this and then stalls the airplane, the airplane may roll rapidly over the top. This could result in a departure or the incipient phase of spin. If the airplane is maneuvering at low altitude when this sequence of events occurs (e.g., while circling to spot moose), the airplane may impact the ground prior to recovery. Also, although washout was not varied during these flight tests, previous FAA experience has shown that stall characteristics are further aggravated when operators of the PA-18 remove the 2.5° of washout at the wing tip, which is not an approved alteration. This condition will result in a rapid roll when the airplane is stalled during turning flight.

4. Handling Qualities

For any given center of gravity/weight, the lateral and directional stability tends to deteriorate as tire size is increased.

5. Stall Warning

Installation of the artificial Stall Warning System on the PA-18 is optional. Most of the PA-18's in Alaska do not have the system installed. The airplane tested did have the artificial Stall Warning System, and a number of test points were obtained with the system deactivated. The airplane as tested does not have an aerodynamic stall warning.

APPENDIX 2

A "COMPLIANCE CHECKLIST" TO CAR PART 3, AS AMENDED TO NOVEMBER 1, 1949

Subpart B—Flight Requirements

Weight Range and Center of Gravity

Section	**Subject**
3.71	Weight and balance
3.72	Use of ballast
3.73	Empty weight
3.74	Maximum weight
3.75	Minimum weight
3.76	Center of gravity position

Performance Requirements—General

3.81	Performance*****
3.82	Definition of stalling speeds*****
3.83	Stalling speed*****

Takeoff

3.84	Takeoff*****

Climb

3.85	Climb*****

Landing

3.86	Landing*****

Flight Characteristics

3.105	Requirements***** (exclude § 3.117)

Ground and Water Characteristics

3.143	Requirements*****

Flutter and Vibration

Section	**Subject**
3.159	Flutter and vibration (vibration only)

*** Indicates topics identified by NTSB Safety Recommendation A-95-13**

Subpart C—Strength Requirements
Symmetrical Flight Conditions (Flaps Retracted)

3.189	Airplane equilibrium

Flaps Extended Flight Conditions

3.190	Flaps extended flight conditions

Unsymmetrical Flight Conditions

3.191	Unsymmetrical flight conditions

Control Surface Loads

3.211	General
3.212	Pilot effort
3.213	Trim tab effects

Horizontal Tail Surfaces

3.214	Horizontal tail surfaces

Vertical Tail Surfaces

3.219	Maneuvering loads

Control System Loads

3.231	Primary flight controls and systems

Ground Loads

3.241	Ground loads
3.242	Design weight
3.243	Load factor for landing conditions

Landing Cases and Attitudes

Section	Subject
3.244	Landing cases and attitudes

Ground Roll Conditions

3.248	Braked roll
3.249	Side load

Subpart D—Design and Construction
Control Systems

3.342	Proof of strength

Landing Gear

3.351	Tests
3.352	Shock absorption tests
3.353	Limit drop tests
3.354	Limit load factor determination
3.355	Reserve energy absorption drop tests

Wheels and Tires

3.361	Wheels
3.362	Tires

Brakes

3.363	Brakes

Subpart F—EQUIPMENT
Landing Lights

3.699	Landing light installation

Subpart G—OPERATING LIMITATIONS AND INFORMATION

3.735	General

Limitations

3.737	Limitations

23.735 Brakes

Original Issue and Subsequent

1. Related regulations and documents are:

a. Regulations

Acceptable means of compliance are found in 14 CFR Part 23. Additional specific information is listed below, including other regulatory material and advisory information. Part 23 sections may be used in showing compliance with the corresponding sections of the former Civil Air Regulations (CAR) for airplanes where the CAR regulations are applicable. For convenience, the former CAR section reference is also shown in parenthesis following the Part 23 section reference:

Part 21, § 21.15	Application for type certificate
Part 21, § 21.93	Classification of changes in type design (TC)
Part 21, § 21.113	Requirement of supplemental type certificate
Part 21, § 21.303	Replacement and modification parts
Part 21, § 21.611	Design changes (TSO)
Part 23, § 23.55	Accelerate-stop distance
Part 23, § 23.75 (3.86)	Landing
Part 23, § 23.143 (3.106)	Controllability and maneuverability: General
Part 23, § 23.231 (3.144)	Longitudinal stability and control
Part 23, § 23.233 (3.145)	Directional stability and control
Part 23, § 23.493 (3.248)	Braked roll conditions
Part 23, § 23.731 (3.361)	Wheels
Part 23, § 23.735 (3.363)	Brakes

Part 23, § 23.1301 (3.652)	Function and installations
Part 23, § 23.1309	Equipment, systems, and installations
Part 23, Appendix D	Wheel spin-up and spring back loads
Part 23, § 23.1529 and Appendix G to Part 23	Instructions for Continued Airworthiness
Part 135, Appendix. A	Additional airworthiness standards for 10 or more passenger airplanes
Part 45, § 45.14	Identification of critical components
Part 45, § 45.15	Replacement and modification parts

b. Advisory Circulars (AC's)

AC 21.303-2H	Announcement of Availability: Parts Manufacturer Approvals—1992 (Microfiche)
AC 23-8A	Flight Test Guide for Certification of Part 23 Airplanes

c. Technical Standard Order (TSO)

TSO-C26c	Aircraft Wheels and Wheel-Brakes Assemblies, with Addendum I

d. Industry Documents

ARP 597C	Wheels and Brakes, Supplementary Criteria Design for Endurance-Civil Transport Aircraft
ARP 813A	Maintainability Recommendations for Aircraft Wheels and Brakes
AIR 1064B	Brake Dynamics
AS 1145A	Aircraft Brake Temperature Monitor System
ARP 1619	Replacement and Modified Brakes and Wheels

2. BACKGROUND

A review of recent replacement and modification wheel/brake system and installation approvals on Part 23 airplanes has resulted in the need to provide FAA guidelines that clearly describe the changes and associated substantiation procedures involved. As contained herein, these guidelines will reflect upon issues that have been identified by industry under Aerospace Recommended Practice (ARP) 1619, revision A, which, in part, concerns the variance in compliance provisions associated with original equipment manufacturers (OEM) and non-OEM applicants. The guidelines will include a description of replacement or modified wheel, wheel/brake parts or assembly changes, a description and examples of associated "major" and "minor" changes, and a description of corresponding laboratory and airplane flight tests needed to ensure that requested changes will result in a continued level of airplane safety and performance.

3. CLASSIFICATION OF REPLACEMENT AND MODIFIED WHEEL/BRAKE CHANGES

a. Replacement of Wheel, Wheel/Brake Parts, or Assembly Changes

A replacement wheel, wheel/brake part, or an assembly change is classified as one in which either the included parts or assemblies that are being changed are of **equivalent** design that will result in an **equivalent** level of certified type performance and safety to that exhibited by either the originally approved parts or assemblies. The change may be approved under a Parts Manufacturer Approval (PMA) by the provisions of Part 21. Under Part 21, § 21.303, an applicant may be eligible for approval of either PMA replacement parts or assemblies, or both, by demonstrating compliance in accordance with the following methods, as applicable**:**

(1) Licensing Agreement

Applicant should provide evidence of a licensing agreement or equivalent with the holder of a Technical Standard Order Authorization (TSOA), Type Certificate (TC), or a Supplemental Type Certificate (STC) together with the submission of any design data covered by the licensing agreement, as determined by the FAA.

(2) Identicalness

Applicant should provide evidence that the parts he produces will be identical in all respects to the corresponding parts of an approved 14 CFR type design, Technical Standard Order, or Parts Manufacture Approval. Data submitted should include all applicable design, material, and process specifications: that is, technical data that would specify all dimensions, tolerances, materials, processes, and specifications to the design of the corresponding part of an approved design.

(3) Airworthiness Requirements (Tests and Analyses)

Applicant should provide evidence—in the form of drawings, test reports, computations, and other substantiating data—showing that the part meets either the applicable Part 23 airworthiness requirements or the certification basis under which the airplane was approved. Compliance to applicable Part 23 airworthiness requirements may include the following:

(a)	Part 23, § 23.55 and Part 135, Appendix A	Accelerate-stop distance for commuter category airplanes and other airplanes that have accelerate-stop distance requirements, including airplanes that have published data such as stopping distances and brake energy/cooling charts in the Airplane Flight Manual.
(b)	Part 23, § 23.75	Landing.
(c)	Part 23, § 23.143	Controllability and maneuverability: General.
(d)	Part 23, § 23.231	Longitudinal stability and control.
(e)	Part 23, § 23.233	Directional stability and control.
(f)	Part 23, § 23.493	Braked roll conditions.
(g)	Part 23, § 23.731	Wheels.
(h)	Part 23, § 23.735	Brakes.
(i)	Part 23, § 23.1301	Function and installation.
(j)	Part 23, § 23.1309	Equipment, systems, and installations.
(k)	Part 23, § 23.1529 and Appendix G to Part 23	Instructions for Continued Airworthiness.

(l) TSO-C26c — Aircraft Wheels and Wheel-Brakes Assemblies, with Addendum 1.

[**Note:** A description of the certification basis in which an airplane was approved can be obtained from the FAA.]

b. Identical Wheel, Wheel/Brake Parts, or Assembly

An identical wheel, wheel/brake part, or assembly is classified as a replacement in which either the included parts or assemblies being changed are of an identical design and will result in an equivalent level of demonstrated performance to that exhibited by either the originally approved parts or assemblies.

c. Modified Wheel, Wheel/Brake Parts, or Assemblies May Be Approved Under a Provision of Part 21

Under Part 21, § 21.303, an applicant may be eligible for approval of modified wheel, wheel/brake parts, or assemblies by demonstrating compliance to methods identified under the above paragraph 3(a)(3) "Airworthiness Requirements (Tests and Analysis)".

d. Major and Minor Wheel, Wheel/Brake Parts, or Assembly Changes

Since design changes appropriate to replacement and modified wheels, wheel/brake parts, or assemblies may involve changes to the original TSO wheel or wheel/brake assembly approval basis under an STC or TC in which the wheel or wheel/brake was installed, compliance to applicable provisions for "major" and "minor" design changes under Part 21, § 21.93 or § 21.611, or both, should also be complied with per the following:

(1) Major Design Changes

A major design change to an existing TSO approved assembly is one that would require a substantially complete investigation of change for compliance to requirements under the TSO, and would result in a new type or model designation. A major design change to an airplane's type design or certification basis is one that could appreciably affect the weight, balance, structural strength, reliability, operational characteristics or other characteristics affecting the airworthiness of the airplane. Examples of such major design changes involving the wheel, wheel/brake parts, or assemblies include, but are not limited to, the following:

(a) Structural material changes and friction material composition changes of heat sink elements that result in changes to FAA-approved performance data.

(b) Reduction of original heat sink mass.

(c) Change in the total brake actuation load or area.

(d) Changes in the friction radius, the total number, or the area of friction faces or elements.

(e) Fuse plug relocation in the wheels, change in release temperature, or a fuse plug redesign where a minor change has not been substantiated.

(f) Changes that would adversely affect the temperature-time profile of a either a wheel or fuse plug, or both.

(g) Relocation of "overpressure release" or "inflation valve."

(h) Redesign of the wheel in a wheel/brake assembly, including a reduction in the wheel or brake structure that could adversely affect wheel strength or fatigue life.

(i) Reduction in the wheel tie-bolt diameter or material strength of bolt and nut.

(j) Change in the wheel bearing size that could or would adversely affect the wheel or bearing load capacity.

(k) Changes in the wheel structural strength, deflection, fatigue life, or weight.

(2) Minor Design Changes

A minor design change to the TSO assembly (or airplane once the assembly is installed) is one that would have no appreciable affect on either the performance of the original TSO assembly or the certification basis (as identified above for major change) of the airplane in which the assembly is to be installed. Investigation into further compliance and FAA approval would normally be limited to minimal functional and compatibility tests. Original model numbers would be retained while part numbers could be used to identify minor changes for TSOA. See paragraph 6.b. "Part Numbering." of this AC in § 23.735 Brakes, for PMA part numbering requirements. Examples of potential minor design changes involving wheel, wheel/brake parts or assemblies might include but are not limited to the following:

(a) Brake friction material changes or heavier heat sink elements that do not result in a change of FAA-approved performance data.

(b) Structural improvements to improve fatigue life.

(c) Paint/corrosion protection changes.

(d) Changes to bleed ports or tube and service fittings.

(e) Revised over-inflation devices.

4. SUBSTANTIATION PROCEDURES

Replacement and modified wheels, wheel/brake parts or assembly changes should be substantiated by conducting the necessary analytical investigations, laboratory testing, or airplane testing, or all of these, to ensure that the change can be made without adversely affecting aircraft safety and associated braking and rolling performance. A substantiation plan should first be proposed by the applicant for FAA approval followed by the applicant's implementation of the plan.

a. Substantiation Plan

A proposed substantiation plan may be presented to the FAA for approval that identifies the applicant's requested change and intended approach in substantiating the change in accordance with the methods addressed under this section. The plan should include the following:

(1) A description of the replacement or modified part or assembly, or both.

(2) An assessment covering the applicable airworthiness requirements involved.

(3) A statement of change that is determined to be either "major" or "minor" along with the basis for the classification relative to the applicable requirements of Part 21.

(4) An assembly drawing reflecting the replacement or modified part or assembly, or both.

(5) Aircraft installation drawings/instructions.

(6) The substantiation method, which includes an analysis/test protocol.

(7) The method of identification and maintenance procedures that will be utilized.

(8) The quality management and quality assurance system under which either the part or assembly, or both, will be produced.

b. Substantiation Requirements

As contained herein, the recommended substantiation requirements for replacement and modified wheels, wheel/brake parts or assemblies are based upon changes for which approval is requested, and the impact a new part or assembly will have on prior certification. If the replacement and modified wheel, wheel/brake part or assembly meets the minimum applicable airworthiness requirements to the product (airplane) on which either the part or assembly, or both, is to be installed, but not the Airplane Flight Manual (AFM) performance data, then the applicant should provide the applicable performance data in an FAA approved AFM or AFM supplement. Depending upon the type and extent of change (as defined under "Section 3, CLASSIFICATION OF REPLACEMENT AND MODIFIED WHEEL/BRAKE CHANGES") and either engineering or pilot judgment, or both, FAA approval will be determined on the basis of compliance with the following substantiation requirements:

(1) Replacement Wheel, Wheel/Brake Parts or Assemblies

(a) Brake-Anti-skid Compatibility

Replacement part or assembly changes, or both, defined under paragraph 3. (d)(2) titled "Minor Design Changes," are considered to be minor whether they are proposed by the original wheel and brake manufacturer who holds the TSO authorization or by another manufacturer seeking to produce a replacement part or assembly. While such changes are not expected to affect braking performance, functional landings may be required as a minimum to verify airplane/pilot/brake/anti-skid combination compatibility (reference Part 23, § 23.735(d)). Normally five (5) non-instrument, functional landings are necessary to verify this compatibility.

(b) Brake Rotors/Stators

In general, changes to the friction surfaces of the aircraft brake, including the stator and rotor, are considered to represent a major change per 3(d)(1), titled "Major Design Changes," unless it can be shown that the change cannot affect the airplane stopping performance, brake energy absorption characteristics, or continued airworthiness (reference Part 23, § 23.735(a)/(e)). In addition, if changes in heat sink friction components are proposed, certain provisions of 4(b)(2), titled "Modified Wheel, Wheel/Brake Parts, or Assemblies," may also be applicable. Changes to continuing airworthiness, such as thermal control, vibration control, etc., should also be considered for the major/minor determination. In this regard, the original manufacturer of the wheel or wheel/brake assembly who holds the TSO authorization may possess data sufficient to show that such changes could be considered minor (e.g., airplane performance would not be affected). On the other hand, a manufacturer other than the original manufacturer who may wish to produce replacement rotors and stators may not have data sufficient to show that performance would not be affected. In this case, the major/minor status would be determined by applicable dynamometer tests per TSO-C26c and some functional airplane tests as a minimum.

(c) Brake Performance Equivalency

It may be difficult to determine identicality, but a finding of equivalency can be shown by additional design, analysis, and dynamometer tests as applicable. A change to an approved part that is determined to be minor can be validated on the dynamometer by a controlled test at the maximum certified kinetic energy capacity of the original brake assemblies from TSOA, or the dynamometer testing may be done to the design landing and accelerate-stop kinetic energy levels appropriate to the aircraft [Reference Part 23, § 23.735 (a) through (e)]. The following dynamometer test protocol is acceptable to validate replacement rotors/stators proposed by an applicant other than the original TSO holder:

1. Use of new stator or rotor parts in the replacement manufacturer's brakes for each dynamometer test will be required in order to minimize test configuration variables. If rebuilt or in-service components other than these fail during testing, it should be realized that the results may be questionable. Suspect tests would be carefully scrutinized by the FAA, and retesting may then be necessary. Test methods, test hardware (including the tire size, ply and condition), and test procedures should be the same to ensure proper comparative evaluations. If brake friction materials are being compared, the heat sinks to be used for maximum certified kinetic energy (KE) testing should not have been subjected to test energies higher than design landing energy.

2. The maximum certified kinetic energies approved under TSOA for the original manufacturer are proprietary data. Therefore, a PMA applicant that desires to maintain the TSOA status of a modified assembly will have to do the testing in this paragraph without knowing the kinetic energy levels the OEM tested for the TSOA. A series of tests may be necessary for a replacement manufacturer to reach the maximum certified level of the original manufacturer's brake. For each succeeding run, the KE will be increased by at least 5 percent over the previous run until the maximum certified KE level is reached. The initial KE level for this series of tests will be at the discretion of the applicant. If maintaining the TSOA is not desired, the PMA applicant may perform dynamometer tests at the airplane derived kinetic energy levels.

3. Maximum braking force pressure, derived from the airplane maximum brake pressure capability, is to be applied during the tests.

4. Fuse plugs may be released or the tire deflated after each test run to reduce the risk to test personnel.

5. A minimum of five (5) functional landings for anti-skid equipped airplanes and a minimum of three (3) functional landings for non-anti-skid equipped airplanes, as described above, are needed.

(d) Worn Brakes [optional]

While there are no provisions under Part 23 to require the evaluation of brake performance using worn brakes, there have been rejected takeoff accidents in which the brakes on subject airplanes were at or very near their completely worn state of energy absorption capability and stopping capability. Therefore, as an **optional** test to a replacement brake performance evaluation (when there is question concerning variances in worn brake performance), it is recommended that such an assessment on the dynamometer be undertaken to support compliance with maximum Rejected Takeoff (RTO) performance in the AFM. Dynamometer tests simulating a maximum energy RTO should be performed on the replacement brake assemblies with individual brakes within 10 percent of their wear limit (e.g., at least 90 percent worn). The tests, used to verify the safety of a replacement brake system and to determine the maximum energy absorption capability of brakes in their fully worn state, should be substantiated as being representative of actual airplane and runway conditions.

(2) Modified Wheel, Wheel/Brake Parts, or Assemblies

(a) Modified Brake Design

This laboratory and airplane test requirement applies to the addition of a major change brake design to an existing airplane for which FAA approved braking performance test data exists. Testing may be performed either for performance credit or to the existing performance level of the aircraft. As provided under examples of 3(d)(1), a modified brake is one that contains new or modified parts that may cause a significant variance in the kinetic energy absorption characteristics, AFM stopping distances and continuing airworthiness of the brake [Reference 14 CFR § 23.735 (a) through (e)]. Substantiating laboratory and airplane flight testing required for approval of a major changed brake will include the following:

1. For improved performance

(aa) Applicable dynamometer tests under TSO-C26c.

(bb) Instrument flight tests to include six (6) takeoffs and six (6) landings. The six landings are to be conducted on the same wheels, tires, and brakes. All tests should be conducted with engines trimmed to the high side of the normal idle range, if applicable.

(cc) Additional tests may be necessary for each airplane configuration change (e.g., takeoff flaps, landing flaps, nose wheel brakes, anti-skid devices inoperative, deactivation of wheel/brakes, etc.).

(dd) Brake system response evaluation.

(ee) Parking brake adequacy. Tires are allowed to skid during maximum power engine checks.

(ff) Alternate braking system stops.

(gg) Fuse plug evaluation.

(hh) Anti-skid compatibility on wet runway.

(ii) Taxi tests, to ensure that ground handling, maneuvering, and brake sensitivity are satisfactory, should be conducted.

(jj) At least two (2) braking stops, one at maximum takeoff weight and one at minimum landing weight, should be conducted on a wet runway to verify brake and anti-skid compatibility.

[**Note:** Improved performance implies an increase in the friction coefficient (mu) versus energy level for the desired operation(s) and may be requested for landing, RTO's, or a specific configuration such as anti-skid "on" only.]

2. For equivalent performance

(aa) Applicable dynamometer tests under TSO-C26c.

(bb) A sufficient number of conditions to verify the existing approved performance levels (RTO and landing for either TSOA levels or Airplane Flight Manual levels). Consideration should be given to verification of fuse plugs, performance verification at appropriate energy levels, and configuration differences, including anti-skid on and off.

(cc) Taxi tests, to ensure that ground handling, maneuvering, and brake sensitivity are satisfactory, should be conducted.

(dd) At least two (2) braking stops, one at maximum takeoff weight and one at minimum landing weight, should be conducted on a wet runway to verify brake and anti-skid compatibility.

[**Note:** Equivalent performance implies that sufficient data will be obtained to verify that the performance level for the change is equal to or better than the existing performance levels. The change may be for the purpose of changing the c.g. envelope, or for airplane configuration changes (such as flap angles), and may apply to specific operations (such as landings).]

3. For extended performance

(aa) Applicable dynamometer tests under TSO-C26c. Consideration should be given to the items in Section 4b(2)(a)(2).

(bb) A sufficient number of conditions to define the extended life and determine equivalency to the existing performance levels. Consideration should be given to the items in Section 4b(2)(a)(2).

[**Note:** Extended performance implies that the existing certification mu versus energy line will extend to establish the braking force level for a proposed change, such as gross weight or the desired maximum energy level, and may be applied to a specific operation (such as landing only).]

(b) Modified Anti-skid System

This airplane test requirement applies to the addition of a new anti-skid system or changes to an existing anti-skid system that may affect airplane performance (e.g., new anti-skid system, or a change from couple to individual wheel control). A sufficient number of either airplane performance tests or functional tests, or both, should be conducted to verify existing approved performance anti-skid "on" levels. In the event an increase of braking performance is desired, full airplane performance testing will be required [reference Part 23, § 23.735 (d)].

(c) Modified Fuse Plugs/Wheels

This item covers the addition of a significant modification to any portion of the existing wheel design on an airplane (change of wheel design, redesign, or relocation of fuse plugs). The following airplane tests can be performed when such changes are made:

1. One airplane braking test should be conducted to show that the fuse plugs will release when excessive energies are absorbed.

2. One airplane braking test should be conducted to verify the maximum kinetic energy at which fuse plugs will not release (fuse plug substantiation). Dynamometer tests are not adequate for this test.

[**Note:** Wheel fuse plug integrity should be substantiated during braking tests where the energy level simulates the maximum landing energy. It should be demonstrated that the wheel fuse plugs will remain intact and that unwanted releases do not occur. One acceptable method to determine this is as follows:]

(aa) Set engine idle thrust at the maximum value specified (if applicable).

(bb) Set tire pressures to the minimum value appropriate for the airplane test weight.

(cc) Taxi at least three miles (normal braking, at least three intermediate stops, and all engines operating).

(dd) Conduct accelerate-stop test at maximum landing energy, maintaining the deceleration rate consistent with the values used to determine performance distance.

(ee) Taxi at least three miles (normal braking, at least three intermediate stops, and all engines operating).

(ff) Park in an area to minimize wind effects until it is ensured that fuse plug temperatures have peaked and that no plugs have released.

Instead of simulating the maximum kinetic energy landing during an accelerate-stop test, an actual landing and quick turnaround may be performed; however, caution should be exercised in order to prevent jeopardizing the safety of the flight crew and airplane if the wheel plugs release right after liftoff, requiring a landing to be made with some flat tires. The following elements should be included in the tests:

(aa) Set engine idle thrust at maximum value specified (if applicable).

(bb) Set tire pressures to the minimum value appropriate to the airplane test weight.

(cc) Conduct a landing stop at maximum landing energy, maintaining the acceleration rate consistent with the values used to determine performance distance.

(dd) Taxi to ramp (three miles minimum with normal braking, at least three intermediate stops, and all engines operating).

(ee) Stop at the ramp. Proceed immediately to taxi for takeoff.

(ff) Taxi for takeoff (three miles minimum with normal braking, at least three intermediate stops, and all engines operating).

(gg) Park in an area to minimize wind effects until it is ensured that fuse plug temperatures have peaked and that no plugs have released. Fuse plug protection of wheels and tires should be demonstrated to show that the fuse plugs will release when excessive energies are absorbed. Normally, this will occur during RTO performance tests.

(d) Accelerate Stop Tests

Accelerate-stop tests for commuter category airplanes and other airplanes are defined under Part 23, §§ 23.55 and 23.735 (e). Accelerate-stop tests should be conducted for all modified wheel, wheel/brake parts or assemblies involving a major design change when this testing was performed for the certification of the original brake assembly. Such tests should include substantiation of the critical maximum brake energy stop (highest ground speed based on the V_1 speed applicable to the maximum altitude and temperature the airplane is certified for according to the FAA approved AFM). On airplanes with wheel fuse plugs, a satisfactory demonstration of fuse plug compatibility should be conducted as stated under Item (2)(c) titled, "Modified Fuse Plugs/Wheels."

(e) Other Substantial Airplane Tests

Depending upon the extent of wheel, wheel/brake part, or assembly modifications that may be involved, there will be a number of airplane tests that should be considered in addition to those above. As applicable to specific changes and to the type of Part 23 airplane involved, the following are tests that may be appropriate and required by the FAA for approval:

1. Brake KE Absorption Tests

Verify that the brake kinetic energy absorption test determined by the laboratory test meets the TSO requirements and the airplane manufacturer's requirements (to be identified by the FAA) [reference Part 23, § 23.735(a) through (e)].

2. Brake Pressure Test

Verify brake pressure tests conducted under the TSO are adequate for the brake system pressure on the airplane, as determined by the manufacturer's brake system pressure data. Conduct a brake pressure test on the airplane if manufacturer's brake system data is not available to verify the adequacy of the TSO test [reference Part 23, § 23.735(c)].

3. Taxi Ground Handling Tests

Perform taxi tests to ensure that ground handling, controllability, maneuverability, and brake sensitivity are satisfactory. Use normal braking, intermediate stops, with all engines operative [see 4b(2)(a), Modified Brake Design].

4. Wet Running Tests

Perform brake stops on a wet runway to verify brake and, if applicable, anti-skid system compatibility [see 4b(2)(a), Modified Brake Design].

5. Function Reliability Tests

Perform function reliability landing stops. Normally six maximum brake landings should be satisfactorily conducted on the same set of wheels, tires, and brakes [see 4b(2)(a), Modified Brake Design].

6. Landing Performance Tests

Determine that the landing performance is adequate to the previously approved performance data shown in the AFM. If the AFM performance data is not available because that it is not required by the airplane certification basis, the manufacturer's data (if available) provided to the pilot should be used as a basis for comparison [see 4b (2)(a) Modified Brake Design].

7. Static Torque Tests

Determine whether there is adequate static torque when parked and during appropriate engine run up conditions [reference Part 23, § 23.735(b)].

8. Brake Response Tests

During the aforementioned tests, brake response characteristics should be monitored for unacceptable vibrations, squeal, fade, grabbing, and chatter. These characteristics may have a destructive effect on the brake assembly components and may be pertinent to endurance of landing gear system components.

5. INSTRUCTIONS FOR CONTINUED AIRWORTHINESS

A PMA applicant may be required to furnish instructions for continued airworthiness if the article on which the part is eligible for installation has an existing set of instructions for continued airworthiness that are not considered adequate for the applicant's PMA part (reference Part 23, § 23.1529).

6. IDENTIFICATION OF PMA PARTS

a. General

Under Part 45, § 45.15, parts produced under a PMA should be permanently and legibly marked in a manner that will enable persons to identify the following:

- It is a PMA part.
- The manufacturer.
- The part number.
- The type certificated product(s) or TSOA article(s) on which it may be installed.

For a part based on an STC, the identification of installation eligible type certified products should include reference to the STC. In accordance with Part 45, § 45.14, parts that have been identified as critical components should be marked with a part number, or equivalent, and serial number or equivalent. If the TC or TSOA holder applies serial numbers to a critical part, the PMA holder should also "permanently mark" their parts with serial numbers.

Note: Due to the harsh environments that wheels and brakes experience, decals or adhesive backed "metalcals" are not considered permanent forms of marking. Metal stamping, etching or permanently affixing a data plate with rivets or drive screws in a non-critical area is satisfactory. Laser marking is also acceptable if it can be read under 2X magnification. Ink stamping is allowed only if more permanent means are not possible.

b. Part Numbering

The PMA holder's part should be numbered such that it is sufficiently different from the OEM holder's part number to be distinguishable. The OEM holder's part number with a prefix/suffix is sufficient for this purpose. The requirements of Part

45, § 45.15(a)(2), to mark with name, trademark, or symbol of the PMA holder may be satisfied by the prefix/suffix if the prefix/suffix is done consistently across the PMA holder's product line. The FAA-PMA letter should show the type approved part number with which the PMA holder's part is interchangeable.

c. Parts Manufactured Under License

When the PMA is issued by showing evidence of a license agreement or equivalent, the PMA part number may be identical to that on the type certificated part providing the PMA holder also meets the requirements of Part 45, § 45.15(a)(1) and (2) to **permanently mark the part** with the letters "FAA-PMA" and the name, trademark, or symbol of the PMA holder.

d. Parts that are Impractical to Mark

In all cases where the part is found by the FAA to be too small (or to have other characteristics that make it impractical) to mark all (or any) of the information on the part, the information not marked on the part should be put on the tag that is attached to the part or marked on the container for the part. If the number of certificated products or TSOA articles on which the part is eligible for installation is too long to be practicable to include with the part, the tag or container may refer to a readily available manual or catalog made available by the PMA holder for part eligibility information.

23.737 Skis

Amendment 23-45 and Subsequent

See § 23.505, Supplementary conditions for ski-planes, for additional guidance about aircraft skis.

23.745 Nose/tail wheel steering

No policy available as of June 30, 1994.

FLOATS AND HULLS

23.751 Main float buoyancy

Original Issue and Subsequent

For a twin float seaplane or amphibian aircraft, the 80 percent excess buoyancy requirement should be applied to both rather than each float.

The rules for twin float aircraft do not address water stability or capsizing. They only require that the aircraft remain afloat with any two compartments of the main floats flooded. The history does not support the position that the aircraft will remain afloat indefinitely without capsizing with two compartments flooded. However, if an unsafe condition exists, certification should be denied under the provisions of Part 21, § 21.21(b)(2). An example of an unsafe condition could be capsizing so rapidly that the occupants could not safely exit. Capsizing that is delayed long enough to permit taxi to the shore or dock is not an unsafe condition. The time to capsize should be listed in the Emergency Procedures Section of the Airplane Flight Manual.

23.753 Main float design

No policy available as of June 30, 1994.

23.755 Hulls

Original Issue

The discussion on capsizing and unsafe conditions in 23.751 applies to this rule also.

Amendment 23-45 and Subsequent

This amendment changed the rule to **prohibit capsizing**.

23.757 Auxiliary floats

No policy available as of June 30, 1994.

PERSONNEL AND CARGO ACCOMMODATIONS

23.771 Pilot compartment

No policy available as of June 30, 1994.

23.773 Pilot compartment view

Amendment 23-14 and Subsequent

See AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes, for guidance on this regulation.

23.775 Windshields and windows

Original Issue and Subsequent

The rule requires the luminous transmittance (LT) be no less than 70 percent when the pilot is seated in a normal flight position. This rule does not specify how the LT is to be measured. Industry, federal practices, standards and airframe manufacturer specifications have specified a minimum LT measurement per Federal Standard 406, Method 3022 or equivalent.

On the basis of available data, we cannot determine that an LT of 70 percent is in itself an unsafe condition. There are other factors such as windshield/window inclination from vertical. The criteria to determine an unsafe condition is a qualitative pilot evaluation.

23.777 Cockpit controls

Original Issue and Subsequent

The FAA has no rule preventing placement of non-flight controls on control wheels, but we consider such installations to be marginal since a switch could easily be confused with microphone or autopilot switches. Approval would require special crew training and AFM guidance to ensure it was used properly.

We strongly recommend that all redundant cockpit controls be symmetrical from one side of the cockpit to the other.

Amendment 23-33 and Subsequent

Section 23.777(c)(4) was added by this amendment. It requires that airplanes with side-by-side pilot seats **and** two sets of powerplant controls, have one set on the left console and one set on the right console. We will consider an Equivalent Level of Safety Finding for airplanes with one set on the left hand side and one on or near the cockpit center line.

The preamble to the 23-33 Amendment shows that floor mounted, mechanical flap controls are acceptable.

23.779 Motion and effect of cockpit controls

Original Issue—Reserved

The original rule only specified primary aerodynamic and throttle motion.

Amendment 23-33 and Subsequent

This amendment requires that the propeller control should move forward to increase rpm. Therefore, a propeller pitch control on the vertical instrument panel does not comply. A switch located in a horizontal position with forward motion to increase rpm does comply. Other designs would have to be considered by an Equivalent Level of Safety Finding. We would consider a propeller pitch control switch that would increase propeller rpm when moved to the "UP" position with a placard to denote rpm change to be eligible as an equivalent.

We have no objection to the propeller pitch control switch being spring loaded against the fine and coarse propeller blade angles. The airplane should be evaluated to ensure no unsafe operating condition will occur with propeller switch in each critical blade position.

23.781 Cockpit control knob shape

No policy available as of June 30, 1994.

23.783 Doors

Original Issue and Subsequent

An Equivalent Safety Finding process for Part 23, § 23.783(b), should include the following:

a. Pilot operated locks when the propeller stops turning.

b. A special operating procedure to ensure the door is opened only after the propeller has stopped turning should be provided in the flight manual and on the inside of the door.

c. If an electric lock is used, complete loss of electric power should not affect opening the door.

d. The door should be designed and placarded so it can be opened from the inside by passengers and from outside by ground personnel.

e. A railing or guard that would deploy to guide passengers away from the propeller plane should be provided as an integral part of the door.

f. If engagement of the engine starter would be an immediate hazard to a person near the propeller, an interconnect between the door and the engine starting circuit should be included in the design.

Amendment 23-34 and Subsequent

The direct visual inspection of the locking mechanism by crewmembers to determine whether external doors, for which the initial opening movement is outward, are fully closed and locked may be conducted from outside the airplane. It will be necessary to provide a means to visually inspect each individual lock of the locking mechanism. Means that do not permit direct visual inspection of each lock are unacceptable unless there is no failure mode of the locking mechanism that would allow a false visual indication that each latch is properly positioned and locked. If optical devices are used from either inside or outside, it should be determined that they are not subject to fogging, to obstruction by foreign objects, or to a false indication of a locked condition.

The locking mechanism should incorporate features that provide a positive means to prevent the door from vibrating open throughout the approved operating envelope. Over center features of the mechanism are not acceptable as a locking means. Also, it should not be possible to position the locks in a locked position if any of the latches are not in the fully latched position.

Amendment 23-36 and Subsequent

Section 23.783(c) was adopted to provide standards that would ensure the opening means of passenger and crew doors were simple, easy to locate, could be operated in darkness, and ensure the doors met particular marking requirements. Overly complex opening means had been identified as a major contributor in accident investigations. The particular marking means are those of § 23.811. Paragraph 23.783(c)(3) was adopted mainly as a measure to ensure that the opening means of passenger and crew doors were kept as simple as possible, and that these doors could be located and opened in a timely manner. Paragraph 23.783(c)(4) was adopted in order to make the location of cabin doors more conspicuous and to facilitate emergency evacuation.

These requirements do not mandate the use of self-illuminated or electrically illuminated external markings. A reasonable and acceptable method of compliance can be found in § 23.807 by substituting “passenger or crew door” where reference is made to “emergency exit.”

Amendment 23-49 and Subsequent

This amendment adds a requirement that passenger doors not be located with respect to any other potential hazard as well as the propeller disk. These hazards could include hot anti-ice, hot de-ice surfaces, and sharp objects on the airplane structure.

23.785 Seats, berths, litters, safety belts, and shoulder harnesses

Original Issue and Subsequent

See AC 21-34, Shoulder Harness-Safety Installations, AC 21-25A, Approval of Modified Seats and Berths Initially Approved Under a Technical Standard Order, and AC 43.13-2A, Acceptable Methods, Techniques, and Practices for Aircraft Alterations.

For aft-facing seats, seat obliqueness should be limited to 15° unless additional occupant protection for side-facing seats is installed.

Part 23 permits side-facing seats, but it does not address the crashworthiness problems of these installations. We recommend that side-facing seat installations be discouraged. If such an installation is made, the following should be applied in addition to any applicable rules from the original certification basis:

a. A sideward facing seat is defined as one in which the plane of symmetry of the occupant makes more than an 18° angle with the vertical plane containing the airplane centerline when viewed from above.

b. Each occupant of a sideward facing seat should be protected from serious head injury when experiencing the inertia forces of § 23.561(b)(2) by either a safety belt and energy absorbing rest that will support the head and torso or by a safety belt and shoulder harness that will prevent the head from contacting any injurious object. There should be adequate padding on any restraining bulkhead. Riding up of diagonal shoulder straps on the neck, which could cause neck injury, and location of attachments and rigidity of the seat support that could cause twisting and compression of the spine should be considered. For a multiple side-facing seat, a passenger seated immediately forward of another passenger cannot be considered an energy absorbing rest (human cushion).

c. Sideward facing seat installations that do not comply with paragraph "b." above should be placarded to prohibit occupancy during takeoff and landing. In any case, the side-facing seats still require one seat belt for each passenger to protect against in-flight turbulence, and the berth should be considered an item of mass for emergency landing conditions of § 23.561.

Amendment 23-7 and Subsequent

AC 23-XX-28 provides information and guidance applicable to the static strength substantiation of the attachment points for occupant restraint system installations, which have both a safety belt and shoulder harness.

Amendment 23-36 and Subsequent

See guidance for § 23.562, Emergency landing dynamic conditions.

Part 23 did not envision more than two seats on the flight deck, although the Part does not prohibit such an installation. The airworthiness standards do not contain adequate standards for an “observer” seat (occupied by an FAA Flight Standards inspector on commuter flights). Therefore, we would expect to apply special conditions to such an installation that would address occupant restraint, emergency egress, and appropriate placarding to prohibit use by a passenger under any circumstances. The special conditions should establish a level of safety equivalent to that established in the certification basis of the airplane, not only for the observer seat occupant but also the crewmember seated in front of the occupant.

23.787 Baggage and cargo compartments

Original Issue and Subsequent

Questions have been raised regarding § 23.787(c), which requires an ultimate inertia forward force of 4.5g for the protection of passengers from any cargo compartment. This regulation is related to Civil Air Regulations, which envisioned a crew compartment forward, a passenger compartment in the middle, followed by a bulkhead and a small cargo/baggage compartment aft. In this concept, the 4.5g was considered adequate based on NASA data that showed g forces become less as distance from the nose increases in a typical crash. Our review of all cargo configurations has led to the conclusion that under § 23.561(b) and (e), the restraining devices should meet the 9g requirements. The up and side load inertia forces are not considered to be applicable in this case where the crew would not be subject to injury from upward or sideward cargo movement.

To modify a passenger plane to an all-cargo configuration, the following items should be considered:

a. The cargo compartment should meet the requirements of § 23.787. Special attention should be given to cargo loading placards and the cargo restraint system.

b. The cargo restraint system, including tie downs and the supporting structure to which they are attached, should be substantiated to the emergency landing ultimate inertia forces in § 23.561(b)(2).

c. The floor loading should be re-substantiated to ensure the floor structure is not overloaded.

d. Emergency egress from an emergency exit or the entrance door should be verified accessible for the crew.

e. A supplement to the Airplane Flight Manual (AFM) weight and balance section that shows the various permissible cargo loading arrangements and cargo restraints should be furnished.

Amendment 23-14 and Subsequent

See AC 23-2, Flammability Tests.

Amendment 23-36 and Subsequent

The rigid moveable/removable cargo restraint bulkhead attached to seat rails and to points along the cabin sidewalls and roof is considered a structure per § 23.787(c). Prior to this amendment, the loads to design this structure were not defined, but the loads for a cargo restraint system and tie downs in a cargo compartment had to withstand an ultimate inertia force of 4.5g. Even though not defined, some certification programs applied a 4.5g ultimate load factor to design a rigid moveable/removable cargo restraint bulkhead in the cabin. The rationale was to bring the sum of occupant protection to a 9g forward load. In this amendment, the ultimate forward load factor for any cargo restraint system and tie downs has been increased to 9g. In this case, the structure can be designed to no load since the occupant protection of 9g has been met by the cargo restraint system and tie downs.

If this structure separates the occupant compartment from the cargo compartment, only § 23.787(c) applies. Section 23.787(b) is applicable if cargo is carried aft of the occupants in the same occupant compartment. The ultimate load factor in § 23.561 has been increased to 18g by Amendment 23-36.

23.791 Passenger information signs

No policy available as of June 30, 1994.

23.803 Emergency evacuation

Amendment 23-34 and Subsequent

See AC 20-118A, Emergency Evacuation Demonstration, for information on how to conduct an emergency evacuation demonstration of a commuter category airplane.

If there is a project for a litter installation for non-ambulatory passengers, then the airplane should be evaluated for compliance with the applicable egress requirements for those passengers who can exit the airplane under their own power per § 23.803. This evaluation can be a simple engineering judgment if it is clear the litter installation will not prevent the safe egress of all non-litter passengers within the allotted time. If there is doubt, a new demonstration should be run that evaluates the ability of non-litter passengers to exit the airplane with special attention to the litter installation and possible obstructions to safe exit.

Amendment 23-46 and Subsequent

This amendment adds a requirement for emergency lighting per § 23.812 to be the only lighting used in an emergency evacuation demonstration when certification of emergency exits is done per § 23.807(d)(4). AC 20-118A is still applicable with the exception of paragraph 5a(3)(vi).

23.805 Flight crew emergency exits

No policy available as of June 30, 1994.

23.807 Emergency exits

Original Issue and Subsequent

"Seating Capacity" as used in this regulation is defined as the number of occupants, both crew and passengers, for which the airplane is certificated. Consequently, removal of installed seats is not justification for removal of certificated emergency exits.

The regulation requires a clear and unobstructed opening. An exemption per 14 CFR Part 11 to § 23.807(b) is acceptable for a seatback that protrudes into the opening if it can be easily pushed forward to clear the exit without requiring an action to unlock/unlatch the seat. If a seatback clears the exit when upright but not when reclined, it is acceptable to placard the seat to be upright during takeoff and landing.

Emergency exits should be located to allow escape without crowding in any probable crash attitude. The inverted position is considered probable for both tail wheel and tricycle gear airplanes. This applies to airplanes with doors, forward sliding canopies, rearward sliding canopies and jettisonable canopies. If escape in an inverted attitude is not obvious or is questionable, then compliance should be demonstrated.

It is not acceptable for certification purposes, except for acrobatic airplanes (§ 23.807(b)(5)), to rely on an emergency procedure requiring canopy jettisoning before an accident occurs. Regarding the acrobatic category, if the canopy is not jettisonable, it should be shown that the canopy can be opened far enough in flight between V_{SO} and V_D to enable the occupants to safely exit the airplane. If jettisonable, it should be shown that the canopy trajectory will not cause injury to the occupants while separating from the airplane between V_{SO} and V_D. Also, if the canopy is jettisonable, it should be demonstrated that the airplane can be safely flown without the canopy, or that an inadvertent jettisoning is shown to be improbable.

Regarding doors between the pilot's compartment and the passenger compartment that are likely to block the pilot's egress in a minor crash landing, there should be an exit in the pilot's compartment. This does not apply to curtains suspended from a rod at the top and made of flexible material without slats on any side.

Doors or folding doors with rigid-frangible materials may jam in a minor crash. Acceptance of frangible doors can be shown by the evacuation procedure in paragraph 23.807(a) below or by the conditions for acceptance of rigid doors in paragraph 23.807(b) below. Rigid doors are only acceptable by placarding the doors to be latched in the open position for takeoff and landing, providing the conditions in paragraph 23.807(b) below are in compliance.

a. The purpose of the test is to demonstrate that the door between the pilot's compartment and the passenger compartment will not block the pilot's escape in the event the door is jammed. Acceptable means of compliance is by demonstrating the door is frangible and the flight crew can egress the airplane without assistance within the 90-second time limit.

(1) The test should be conducted in an airplane or a mockup that conforms to the production airplane interior configuration that contains a bulkhead and door to be tested. The door should be closed to simulate jamming. If fragments from the broken door could obstruct the escape route of passengers and an emergency evacuation demonstration is required by either airworthiness or operating rules, then consideration should be given to including passenger participants in the test. In this case, refer to § 23.803 for guidance.

(2) Two participants representing a pilot and a copilot will be used in the test. They should be persons with no particular escape abilities. The approximate stature and weights for the participants should be a female 60 inches tall weighing 102 pounds and a male 74 inches tall weighing 210 pounds (5th to 95th percentile). The female participant will break the door and be the first person through the exit without assistance from the male participant. Instructions for enhancing the egress should be limited to those instructions that are provided in either the FAA approved Airplane Flight Manual (AFM) or on related placards, or both.

(3) Determine that the lighting simulates night lighting with no moonlight or starlight. Lighting may be allowed at ground level to aid in leaving the area near the airplane providing the lighting is kept low and is shielded so it does not aid in evacuating the airplane.

(4) Participating personnel should be informed of the purpose of the demonstration and of the safety precautions. Safety of participants is the responsibility of the applicant and safety procedures should protect the applicants without impacting the test results. Participants may wear protective gear such as helmets, but such gear, tools, or any other device should not be used to break through the door.

(5) The time limit is 90 seconds whether or not passenger participants are used in this demonstration.

(6) Information advising the flight crew that the door is frangible should be placarded on the door(s) and should be noted in the Limitations Section of the AFM.

b. Rigid doors (those with stiff members that may jam in a minor crash) may be approved providing they are placarded to be latched open during takeoff and landing and under the following conditions:

(1) The opening and latching should be included in the Normal Procedures Section under the Before Takeoff and Before Landing Checklists of the AFM.

(2) With the door latch in the fully open position, the latch should be able to withstand the loads from the ultimate forces relative to the surrounding structure, per § 23.561.

(3) Flight crew members should be able to open and latch the door with their safety belts/shoulder harnesses fastened, if required by either airworthiness or operating rules.

(4) If certification for night operation is requested, the pilot's compartment—with the doors open—should be free from glare and reflections that could interfere with a pilot's vision, per § 23.733.

(5) The doors should be placarded in accordance with § 23.1557. The placards should state that the doors are to be latched in an open position before takeoff and landing. Placard information should be in the Limitations Section of the AFM.

Regarding all cargo use of a Part 23 airplane, the number of exits cannot be reduced for this configuration since the number of exits is based on the "Seating Capacity." However, if the airplane is configured as all-cargo (no passengers), the cargo should be loaded in such a manner that at least one emergency exit or regular exit is available to provide all occupants with an unobstructed exit. This means emergency exits may be blocked off by loaded cargo. However, we advise that two exits, one on either side of the airplane, should be left usable to allow an alternate egress when one exit is blocked from inside or outside following an emergency. Consideration should be given to placarding all exits that are blocked off, both inside and outside, so minimum time is spent by rescue personnel in determining which exit is available to airplane occupants. The door between the pilot's and cargo compartments is still subject to the rigid/frangible door guidance listed in this section.

If the airplane is configured for both passenger and cargo (Combi), the requirements of this section should be met for the passenger compartment. In addition, cargo should be located so that it does not obstruct either access to or use of any required emergency or regular exit; so that it does not obstruct the use of the aisle between the crew and passenger compartment; and so that it meets the additional requirements of § 135.87.

Amendment 23-34 and Subsequent

This amendment added emergency exit requirements for commuter airplanes. Included are emergency exit marking requirements as well as those in §§ 23.783 and 23.1557. The additional emergency exit marking requirements in § 23.1557(d) regarding the red operating handle and placard that provides door opening instructions are not mandatory for the passenger entrance door. However, § 23.807(b)(3) requires markings for easy location and operation of the exit even in darkness, and § 23.811(b) requires the illumination of the exit sign. As an added safety feature, it is recommended that the operating handle be self-illuminated and marked with a red arrow and the word "OPEN" in red letters placed near the head of the arrow. If necessary, other pertinent instructions for opening the door should also be in red.

This amendment requires three emergency exits as well as the entrance door for commuter airplanes with passenger seating from 16 to 19. Part 25, § 25.807, requires two Type III emergency exits on opposite sides of the cabin. It is possible for an applicant to use Part 25 for emergency exits. To do so requires a petition for exemption per Part 11, and compliance to Part 25, §§ 25.807, 25.561(b)(3)(iv), 25.783, 25.809, 25.811, 25.812, 25.813, 25.815, and 25.817.

An integral stair, if installed at an entrance door, should be designed so it does not reduce the effectiveness of the door as an emergency exit under the inertia forces of § 23.561 and following the collapse of one or more legs of the landing gear. An actual demonstration of this failure mode is beyond the intent of this rule. It should be shown by orthographic drafting techniques or test (i.e., ground plane under an airplane to simulate various attitudes) that with the various combinations of collapsed landing gears and resulting airplane attitudes, the exit effectiveness is not reduced. This is done with no fuselage deformation.

There are no standards for ejection seats in Part 23. If an applicant needs an ejection seat to meet the emergency exit requirement in § 23.807, an equivalent level of safety will have to be justified.

Emergency Exit Size and Shape

Background

CAR 3.387 and 14 CFR Part 23, § 23.807, have required that all emergency exits have sufficient size and shape to admit a 19 x 26 inch ellipse. Time to egress through an exit is related to the total open area and the most critical dimension of the exit. The area of a 19 x 26 inch ellipse is 388 square inches. Studies for emergency evacuation demonstrations with the standard ellipse have shown that the duration to egress was equal or less with other exits having a total open area equal to or greater than 388 square inches and the most critical dimension, width or height, greater than 19 inches, but lacking the shape to admit a 19 x 26 inch ellipse.

Acceptable Means of Compliance

Alternatives for compliance to the airworthiness standards are permitted by an equivalent level of safety. One method for determining compliance by an equivalent level of safety is by the test procedure below. Demonstrations have shown that the emergency exit size and shape greatly affect the time and ease of an emergency evacuation. An equivalent level of safety should only be considered if the exit meets the logical limits which correspond to the standard exit; that is, the total open area is equal or greater than 388 square inches and the most critical dimension, width or height, is not less than 19 inches. These limits for area, width, and height were established after considering human factors, evacuation demonstrations, and existing airworthiness standards.

Test Procedure

Area of opening. The following factors should be considered when measuring or computing the area of opening:

a. Firm protrusions that would hamper egress should be eliminated from the minimum required exit opening. Examples are seals or escape latches that will not easily compress, move, or fold out of the opening with the motion of a person moving through the opening.

b. When a compressible seal protrudes into an opening, the seal may be in the compressed condition when measuring or computing the opening area.

c. During the comparison test, the emergency exit opening used as a standard is an opening that will allow passage of a 19 x 26 inch ellipse with a major axis being in a vertical position, a horizontal position, or any other position.

d. The area leading to the opening should be clear and unobstructed. Minor obstructions could be acceptable if there are compensating factors to maintain the effectiveness of the exit; that is, a total effective open area of 388 square inches and the most critical dimension, width or height, not less than 19 inches. For example, soft seatback cushions may constitute minor obstructions if the cushion can be readily moved away from the exit and the exit can be easily opened, and if the cushion in its normal position does not prevent identification of the exit or obscure the exit marking.

Comparison Test Conditions. The comparison test will determine the difference in mean escape time between the proposed and standard exit or exits.

a. A mockup of a section of the fuselage may be used. The arrangement of exits, passenger seats, and the step-up and step-down distances from the sill to the wing or step may be simulated. Ramps or stands are permitted to assist participants in descending from a wing when over-wing exits are used if the acceptance rate of the ramp or stand is no greater than that of the assist means of the airplane in an actual crash landing situation. Mats may be used on the floor or ground to protect participants. No other equipment that is not part of the airplane's emergency evacuation equipment may be used to aid the participants in reaching the ground.

b. At the start of each trial, participants should be seated as called out in AC 20-118A, Emergency Evacuation Demonstration.

c. Participants should not be permitted any "practice" runs, but they may be briefed on the purpose of the test to demonstrate a rapid emergency evacuation of the airplane. They should not be briefed that the test is to compare exits. An example of an acceptable instruction would be to pass through one foot first, followed by the head and the other foot. The briefing should be the same for each trial.

d. The test should be conducted under dark or simulated dark conditions for both standard and proposed exit configurations per the Compliance Inspection Requirements of AC 20-118A.

e. The Participant Composition should be as specified in AC 20-118A.

Statistical Design. An acceptable statistical design is as follows:

a. There should be 15 or more participants for each exit configuration to be tested, including the standard configuration.

b. The participants should be assigned to the number of subgroups corresponding to the number of exit configurations to be tested. As noted in paragraph a., each subgroup should have at least 15 people unless the seating configuration is less than 15. In this case the following procedures should be used:

(1) The subgroups should be divided into sub-subgroups of approximately equivalent size where the sub-subgroup size is equal to or less than the seating capacity of the airplane. The egress time of the sub-subgroups is totaled to constitute the subgroup time.

(2) When a mockup for an airplane is used, even if the number of passenger seats is less than 15, the total subgroup of 15 participants may participate at the same time providing the increase of space from the standard mockup for the additional subjects does not degrade the comparison tests. Under these conditions, the participants with the least physical agility should be in the most critical positions.

c. The subgroups should be as neatly alike as possible with respect to physical agility, age, sex, and weight. This can be achieved by first dividing the group by age and sex then subdividing each age/sex group at random into the required number of subgroups.

d. Each subgroup should test each configuration, but the order of trials should be different for each subgroup as well as chosen in accordance with the Latin Square Principle. This principle is that each configuration be tried once by each subgroup and appear once in each possible order. Thus if there are two configurations to be tested and, therefore, two subgroups A and B, then Subgroup A should first try the standard configuration followed by the proposed configuration; Subgroup B should perform the trials in the reverse order. This arrangement eliminates the effects of an individual’s learning, fatigue, and agility.

Recording of Trials. Recording should be done as follows:

a. Motion pictures or video recordings, sound or silent, should be made to analyze the trials for difficulties with an exit, individual escape times, and other performance factors.

b. A large clock with a second hand should be placed in the camera field so that time can be recorded or synchronized electric cameras may be used with the time superimposed in the film processing. A signal light to indicate the beginning and end of each trial should also be arranged in the field of view of the camera.

c. Evacuation time should be rounded to the nearest second. The timed demonstration is performed per the Evacuation Section of AC 20-118A.

Evaluation of Results. The evaluation should be performed as follows:

a. The effectiveness of the proposed exit or exits compared with the standard exit or exits is determined by comparison of the average time of the subgroups to pass through each exit tested. The effect of subgroup learning is canceled by the Latin Square Principle.

b. It is possible that one group may contain one or two persons who find it difficult to go through the exits. The Latin Square Principle will cancel such unbalance between subgroups.

c. It may happen that an individual may, through chance, have considerable difficulty with an exit, but their performance may compare with average performance of other individuals. A study of the individual escape times will enable such occurrences to be evaluated and will assist in the final determination of the acceptability of the proposed exit or exits.

d. A proposed exit configuration is acceptable when its egress time is equal to or less than the time required to pass through the standard exit.

Type Certificate Data Sheet. An equivalent level of safety should be part of the type certification basis and noted on the type certificate data sheet. Suggested wording is, "Equivalent Safety Findings: Section 3.387 of the CAR and Section 23.807 of 14 CFR Part 23, emergency (particular) exit in accordance with AC 23-XX-29, Systems and Equipment Guide for Certification of Part 23 Airplanes (in draft)."

23.811 Emergency exit marking

Amendment 23-36 and Subsequent

For small airplanes with emergency exits openable from the outside, the FAA recommends that markings be added to the outside of all exits as follows:

a. Outline the exit with a band of a contrasting color from the surrounding fuselage surface.

b. Mark the corners of the exit in a conspicuous manner.

c. Outline the exit handle with a band of a contrasting color.

d. Mark the exit with any other conspicuous visual identification scheme.

e. Install a decal on the outside surface of the exit or the surrounding surface adjacent to the exit that shows the means of opening the exit, including any special instructions if applicable.

Passenger exit signs should have an initial luminescence of at least 160 microlamberts, and should be replaced when its luminescence decreases below 100 microlamberts.

23.812 Emergency lighting

No policy available as of June 30, 1994.

23.813 Emergency exit access

No policy available as of June 30, 1994.

23.815 Width of aisle

Amendment 23-34 and Subsequent

The main passenger aisle width is the minimum distance between seats measured without occupants. This distance is measured without compressing the seat fabric or cushions, and with the seats and other aisle constraints in their most adverse position.

23.831 Ventilation

Original Issue and Subsequent

The use of an alternate air supply, either automatic or manual, that picks up air from within the engine compartment is unacceptable for cabin ventilation because of possible contamination from fuel, oil, or exhaust leaks.

Halon 1301 may be safely used in concentrations up to 10 percent in airplane cabins. Ventilation in airplane cabins is sufficient for the agent to disburse in less than 5 minutes, so the time limit need not be considered if the concentration is held below the 10 percent limit. Halon 1211, however, should not be used in airplane cabins.

Amendment 23-34 and Subsequent

For pressurized airplanes, if hazardous accumulations of smoke are found to be reasonably probable in the cockpit area, smoke evacuation to a non-hazardous level should be readily accomplished from full pressurization to minimum safe levels (per § 91.211). Smoke evacuation procedures should be included in the Airplane Flight Manual, Emergency or Non-Normal (Abnormal) Procedures Section, or on approved placards.

PRESSURIZATION

23.841 Pressurized cabins

Original Issue and Subsequent

Paragraph (c) in § 23.841 requires there be a means to rapidly equalize the pressure differential. Assuming isothermal conditions, the time for the pressures to equalize depends on the cabin volume, the effective area of the safety-dump valves, the cabin inflow, and the pressures inside and outside the cabin. If the size of the effective area of the valve is small in comparison to the cabin volume, the rate of pressure change may be too slow to equalize the pressures before an adverse event could occur. The time period to rapidly equalize the pressures should consider maximum certificated cabin pressure differential, operation of the pressurization system, and either operation of the emergency exits or the cabin entrance doors, or both. When landing the airplane under emergency conditions, the safety-dump valve should have sufficient flow capacity to rapidly equalize the cabin pressure within a time period so that the cabin doors and emergency exits can be opened and evacuation is not impaired. Time to equalize the ambient and cabin pressures should be demonstrated.

Paragraph (f) of § 23.841 requires a warning device for safe or preset pressure differential and absolute cabin pressure. A warning is interpreted to convey the need for an immediate corrective action, so it may not operate unless there is a failure, and the visual indication should be red per § 23.1322. Red lines on altimeters or pressure indicators are used to indicate operating limits, but they are not acceptable warning means.

Inflatable door seals, if installed, are subject to the requirements of this rule.

Amendment 23-14 and Subsequent

This amendment requires that cabin pressure altitude not exceed 15,000 feet in any probable failure for airplanes certificated to operate over 31,000 feet. It is not appropriate to use an emergency descent procedure to demonstrate compliance to this rule when compliance can be achieved through design. The Airplane Flight Manual, Emergency Operations Section, should include an emergency descent procedure for use in a rapid decompression from any failure not withstanding the probability of its occurrence.

Amendment 23-17 and Subsequent

This amendment established 10,000 feet as the maximum absolute cabin pressure for operation of the pressure altitude warning. Therefore, the pressure sensors used in the warning system cannot have an operating set point and tolerance that would prevent the warning from being given at or before 10,000 feet. A feature that automatically changes the warning altitude to 15,000 feet for operations at field elevations above 10,000 feet is acceptable to prevent nuisance warnings.

The following material is a means of compliance to § 23.841(b)(3) that requires a means by which the pressure differential can be rapidly equalized. Section 23.841(b)(6) offers a provision for a warning indication at the pilot station to indicate when a cabin pressure altitude of 10,000 feet is exceeded.

1. RELATED 14 CFR PART 23 SECTIONS. These acceptable means of compliance refer to certain provisions of Part 23 and the corresponding provisions of Part 3 of Civil Air Regulations (CAR) in the case of airplanes for which those regulations are applicable. Listed below are the applicable and the related Part 23 sections with the corresponding CAR sections shown in parenthesis:

a. § 23.365 (3.197)

b. § 23.775(c) (3.383)

c. § 23.841 (3.395)

d. § 23.843 (3.396)

2. DISCUSSION OF REQUIREMENTS. In discussing these requirements, a brief history on the development of the applicable airworthiness regulations is first presented. The purpose of the airworthiness requirements for small airplanes is then explained.

a. Rapidly Equalizing the Pressure

(1) History. The requirement for a means by which the pressure differential can be rapidly equalized was introduced in the airworthiness regulations for pressurized cabins for transport category airplanes when Part 04 of the CAR became effective on November 9, 1945. Due to the trend to develop pressurized cabins for small airplanes, the 1956 Annual Airworthiness Review established similar requirements for pressurized cabins for small airplanes. The criteria were developed by using the principles that were applicable to pressurized cabins on transport category airplanes since most of the cabin pressure control system design for small airplanes drew heavily upon the equipment designed and developed for transport category airplanes. As a result, many of the provisions added to Part 3 of the CAR by Amendment 3-2, effective August 12, 1957, were substantially the same as those which applied to transport category airplanes. Under the recodification program in 1965, Part 23 replaced Part 3 of the CAR and these requirements are now in § 23.841(b)(3).

(2) The purpose of this requirement is to provide the crew with a means to rapidly equalize the differential pressure to permit quick opening of the emergency exits and entry door(s) in the event of a gear up landing under emergency conditions. This means may be used for other events such as over pressurization and reducing cabin contamination. These functions are described in further detail as follows:

(i) Due to a malfunction in the pressurization system or abnormal operational conditions, the cabin pressure is above normal conditions during the airplane landing phase. In this case, the cabin pressure may be vented by the safety-dump valve operated through a manual controller or triggered by the landing gear safety switch so the emergency exits and the cabin entrance doors could be opened.

(ii) If a failure such as a cracked window or windshield occurs, the cabin pressure should be capable of being rapidly reduced so the loads due to cabin pressure differential can be reduced accordingly.

(iii) When a threatening cabin overpressure condition exists due to cabin pressurization system malfunction, the cabin pressure can be reduced by the safety-dump valve to prevent a structural failure of the pressure vessel.

(iv) When the cabin air becomes contaminated by smoke, fumes, etc., the cabin safety-dump valve may be used, depending on the conditions, to assist the pressurization or ventilation system, or both, in evacuation of the cabin air to reduce the contaminants.

b. Cabin Pressure Altitude Warning

(1) History

(i) The cabin altitude warning and many of the provisions for pressurized cabins for small airplanes were added to Part 3 of the CAR by Amendment 3-2, effective August 12, 1957. Section 3.395(f) of Part 3 of the CAR required, in pertinent part, that the pilot be provided a warning when safe or preset limits on pressure differential and on absolute cabin pressure were exceeded.

(ii) In May 1958, a quantitative requirement was introduced in the airworthiness regulations when FAA established policy for altitude warning on the sport category airplanes. This policy, which was set forth in § 4b.375-l of CAR Part 3, required that the warning for cabin pressure would meet the applicable requirements if it occurred when cabin absolute pressure was reduced below that equivalent to 10,000 feet. Under the recodification program in 1965, Part 25 replaced Part 4b of the CAR and the 10,000 feet warning policy was carried over as an appropriate means of meeting the warning requirements in § 25.841.

(iii) As part of the First Biennial Airworthiness Review Program in 1975, Amendments 23-17 and 25-28, which changed Parts 23 and 25 respectively, were issued and became effective February 1, 1977. Amendment 25-28 transmitted a minor change to § 25.841 as follows: It changed "cabin absolute pressure is below that equivalent to 10,000 feet" to "cabin pressure altitude exceeds 10,000 feet." Amendment 23-17 brought into § 23.841 of Part 23 a warning indication when the cabin pressure altitude of 10,000 feet mean sea level (MSL) is exceeded. The preamble for this change indicated this proposal was adopted because a large number of small airplanes had such a warning and many pilots had begun to rely on this warning.

(2) The purpose of the cabin pressure altitude warning requirement is to indicate a warning at the pilot station when the cabin pressure altitude is greater than 10,000 feet MSL. A possible hazardous condition could be when the airplane reaches the operating altitude, which is greater than 10,000 feet MSL, and a malfunction in the cabin pressurization system occurs. If there was no warning for cabin pressure altitude, the cabin pressure altitude could slowly increase undetected to the airplane altitude, and the crew and passengers could become unconscious due to hypoxia. The effects of hypoxia are usually encountered when the flight crew is exposed to altitudes above 10,000 feet during extended flights.

3. ACCEPTABLE MEANS OF COMPLIANCE

Warnings and Cautions. Section 23.1322 provides specific requirements for the assignment of red and amber for visual indications. Specifically, for abnormal operational or airplane systems conditions, a "caution" should be generated for crew awareness and subsequent crew action may be required; the associated color is amber. Under emergency operational or airplane systems conditions, a “warning” should be generated for immediate crew recognition and when corrective or compensatory action may be required; the associated color is red. If the cabin pressure altitude warning is a visual indicator, it should be red to indicate a hazard.

23.843 Pressurization tests

Original Issue and Subsequent

This rule applies to all doors. This includes doors that open outward, doors that open inward, and emergency exits.

FIRE PROTECTION

23.851 Fire extinguishers

Amendment 23-34 and Subsequent

See AC 20-42C, Hand Fire Extinguishers for Use in Aircraft, for guidance.

23.853 Passenger and crew compartment interiors

Original Issue and Subsequent

See AC 23-2, Flammability Tests.

23.855 Cargo and baggage compartment fire protection

No policy available as of June 30, 1994.

23.859 Combustion heater fire protection

No policy available as of June 30, 1994.

23.863 Flammable fluid fire protection

Amendment 23-23 and Subsequent

The intent of this rule is to minimize the probability of igniting flammable fluids for areas containing potential ignition sources and systems that might be subject to flammable fluid or vapor leakage. There should be a means to minimize the probability of ignition, backed up by a means to minimize the resultant hazard if ignition does occur. The rule does not go so far as to make the entire airplane a “designated fire zone.”

Where fire detection and extinguishing means might be impractical, the back up provisions could, for example, consist of a means to limit fluid leakage and fireproofing or isolation of critical parts. Therefore, compliance with § 23.863 could be accomplished with a means to limit fluid leakage, minimizing the probability of ignition, fireproofing or isolating critical parts.

If a finding is made that flammable fluids or vapors cannot escape into an area containing a potential ignition source or if the fluids are nonflammable, this rule would not apply to that area. Design measures could support the finding such as (1) shrouding (sealing off) of all potential ignition sources; or (2) shrouding or sealing off of all flammable fluid/vapor sources. In either case, it should be ascertained that the means will continue to serve its function following any single failure of the system or component it is isolating from the area.

23.865 Fire protection of flight controls, engine mounts, and other flight structure

Amendment 23-14 and Subsequent

The engine mounts refer to the aircraft structure for mounting the engine and not the mount pads or attachment points, which are integral parts of the engine.

The intent of the regulations regarding engine mounts is that the engine remain in place with a fire heating an engine mount. We do not intend to cover the case of a general conflagration where the entire engine compartment is burning. Therefore, an applicant should design sufficient load paths for the engine to remain in place with a localized fire.

For purposes of this rule, landing gears are not considered to be flight structures, so fireproofing or shielding landing gears is at the option of the manufacturer.

Shielding made from fireproof materials in Part 23, § 23.1191(h), may be used without flame testing. While the shielding may be made of fireproof materials that don't require testing, means of installing the shielding such as sealers, adhesives, etc. should be shown to not reduce the efficacy of the shielding. Shielding materials subject to corrosion should be appropriately protected. Shielding need not be fireproof if it protects the enclosed structure to an extent equivalent to the enclosed structure being fireproof by itself.

The effectiveness of such shielding or fireproof materials should be determined by subjecting the shielded or fireproof structure, or control, to flammability testing as defined in AC 23-2, Flammability Tests. Before removal of the flame at the end of the test, loads should be applied to the shielded structure or control to demonstrate that it can withstand the loads expected to occur during completion of the flight. These loads can be treated as ultimate loads.

ELECTRICAL BONDING AND LIGHTNING PROTECTION

23.867 Electrical bonding and protection against lightning and static electricity

Amendment 23-7 and Subsequent

Lightning protection of VFR airplanes was considered because there is a technical possibility that a lightning strike on a VFR airplane could occur. However, the probability and consequences of a VFR lightning strike are more pertinent than the possibility. The hundreds of millions of hours of service history illustrate neither a probability nor a consequence worthy of requiring the customer's assets be expended on lightning certification of this class of airplane. Therefore, this section is not applicable to VFR-Only airplanes.

MISCELLANEOUS

23.871 Leveling means

No policy available as of June 30, 1994.

Subpart F—Equipment

GENERAL

23.1301 Function and installation

Original Issue through Amendment 23-19

A system/equipment that is **neither** essential for safe operation **nor** required by airworthiness or operating rules may be approved if it is not a hazard in normal operation or when it malfunctions/fails. It does not have to perform its intended function.

Section 23.1301 requires that instruments be installed in accordance with prescribed limitations. Therefore, if an instrument manufacturer specifies any allowable installation requirements (i.e., panel slope for gyroscopic instruments), the installer should stay within the limitation(s).

See AC's 23-8A, Flight Test Guide for Certification of Part 23 Airplanes; 20-67B, Airborne VHF Communications Equipment Installations; and 20-41A, Substitute Technical Standard Order (TSO) Aircraft Equipment.

Amendment 23-20 and Subsequent

All installed systems/equipment should perform their intended functions. For systems/equipment neither essential for safe operation nor required by airworthiness or operating rules, the manufacturer should define the intended functions that the FAA will verify as part of the certification project.

Section 23.1301 requires that instruments be installed in accordance with prescribed limitations. Therefore, if an instrument manufacturer specifies any allowable installation requirements (i.e., panel slope for gyroscopic instruments), the installer should stay within the limitation. We recommend that the slope be no more than 15°. If applicants want a slope greater than 15°, they should show conclusively by tests or analyses that the instrument will function properly when subjected to all expected airplane maneuvers.

23.1303 Flight and navigation instruments

Original Issue and Subsequent

Altimeters

A servo-corrected altimeter may be installed as the required altimeter provided an electrical failure is apparent to the pilot and the altimeter meets the accuracy requirements of the standard pneumatic altimeter without electrical power. Or, a servo-driven or servo-corrected altimeter with insufficient accuracy may be installed with at least one pneumatic altimeter installed for use by the pilot. On aircraft requiring two pilots, instruments should be located in front of each pilot. Therefore, either the pneumatic or the electrical altimeter can be installed in either location. The desired level of safety could be achieved without a pneumatic altimeter if the electrical supply is ensured. The provision of a pneumatic altimeter is usually more practical than the design and installation of a suitably reliable electrical supply system.

Altimeters employing a "Smiths Law" correction are acceptable provided they are identified by an appropriate part number, marked clearly for use only on the airplane on which they are calibrated, and information is available to the pilot to enable manual correction computations at airspeeds other than those used in designing the instrument correction.

Amendment 23-17 and Subsequent

See AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes, for information on Free Air Temperature Instruments and Speed Warning Devices required for turbine engine powered airplanes.

Altimeters

For installation of electronically powered altimeters, when the regulations were promulgated for the requirements of altimeter systems, only pneumatic altimeters were envisioned. The minimum level of safety established by the regulation was based on the reliability and failure modes of pneumatic altimeters.

a. Service history has shown numerous occurrences of complete loss of primary electrical power for both single-engine and multiengine airplanes. The complete loss of altimeter information from a failure of primary power could adversely affect the safe operation of the airplane and is considered an unsafe feature. An electrically powered altimeter installation should have a level of safety equivalent to a pneumatic altimeter installation, and it may be found acceptable if there is no unsafe feature or characteristic.

b. In assessing an electrically powered altimeter with pneumatic reversion capability, the means of providing continuous and usable altitude information should be considered upon a failure of the primary electrical power. An electrical powered altimeter may be acceptable under one of the following types of installation:

(1) An electrical powered altimeter with pneumatic reversion that provides a power failure warning as an integral part of the instrument's display, and appropriate correction information is provided for the reversionary pneumatic mode.

(2) An electrical powered altimeter that is provided with an alternate power source independent of the electrical generating system. Adequate information should be provided to the pilot on the operating limitations and procedures when operating on the alternate power source.

(3) An electrical powered altimeter without a pneumatic reversionary mode may be installed at any pilot's position provided a pneumatic altimeter is located on the instrument panel so that it is found to be usable from any pilot's flight position.

LORAN-C

See AC 20-121A, Airworthiness Approval of Airborne Loran-C Navigation Systems for Use in the U.S. National Airspace System (NAS), for information on Loran-C installations.

Global Positioning System (GPS)

See AC 20-138, Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Supplemental Navigation System.

23.1305 Powerplant instruments

Original Issue and Subsequent

a. Fuel Pressure Indication

Paragraph (b)(4)(ii) of § 23.1305 requires fuel pressure indicators for pump-fed engines. An equivalent level of safety finding can be made for a warning (red per § 23.1322) light set to operate when the primary pump fails and the emergency pump must be manually activated. A caution (amber per § 23.1322) light is acceptable for an automatic switchover to the emergency fuel pressure pump. Also, a fuel flow indicator can be used to indicate the primary pump is operating normally if there is a placard or Airplane Flight Manual (AFM) to advise the pilot on how to determine primary pump condition from fuel flow information.

b. Powerplant Instrument Marking

See AC 20-88A, Guidelines on the Marking of Aircraft Powerplant Instruments (Displays). In consideration of the policy in Item 6d of AC 20-88A, reciprocating engine parameter instruments where the rate of change is small or nearly steady state (i.e., cylinder head temperature, exhaust gas temperature, or turbocharger inlet temperature) may use direct reading digital (alphanumeric) instrument displays with ancillary displays such as warning lights. These ancillary light displays should include amber lights for takeoff/cautionary ranges and red lights for appropriate limits. Placards containing operating range and limitation information should also be included.

c. Fuel Flowmeters

This guidance is applicable to the installation of fuel flowmeters in small airplanes with continuous-flow, fuel injection, and reciprocating engines.

1. RELATED REGULATIONS

These acceptable means of compliance refer to certain provisions of Part 23 and the corresponding provisions of the former Part 3 of the CAR in the case of airplanes for which those regulations are applicable. Listed below are the applicable Part 23 sections with the related CAR sections shown in parentheses:

Part 23 Sections

§ 23.773	(3.382)
§ 23.955	(3.433)
§ 23.961	(3.438)
§ 23.991	(3.449)

§ 23.993	(3.550)
§ 23.1183	(3.638)
§ 23.1191	(3.624)
§ 23.1305	(3.655)
§ 23.1337	(3.673)
§ 23.1529	
§ 23.1541	(3.755)
§ 23.1543	(3.756)
§ 23.1549	(3.759)

2. BACKGROUND

a. Recently there has been a trend toward replacing fuel pressure indicators and analog reading fuel flowmeters with digital fuel flowmeters/fuel totalizers. New developments in microprocessor technology have resulted in digital fuel flow computer systems that are economical, accurate, and that provide data for improved fuel management. These digital fuel flow computer systems also have features for displaying total fuel consumed, total fuel remaining, and time remaining; however, the accuracy of these readings is dependent upon the initial fuel supply entered into the fuel computer. The precise digital readings that are displayed to the nearest tenth of a gallon could give a pilot a false sense of accuracy and security, especially the readings for total fuel remaining and time remaining.

b. Digital fuel flowmeters are not a required powerplant instrument except for turbine engine airplanes with an Amdt. 23-43 certification basis. They are optional equipment and should not be considered replacements for fuel quantity or fuel pressure indicators. Different interpretations of the regulations have caused conflict and lack of national standardization on installation of fuel pressure indicators and fuel flowmeters/fuel totalizers in small airplanes that have continuous-flow, fuel-injection systems in reciprocating engines. Inquiries from members of the aviation community and manufacturers have indicated a need for information concerning approval and installation of digital fuel flowmeters/fuel totalizers. The location of the fuel flow transducer in the fuel system is critical for measuring the total fuel flow consumed by the engine and maintaining engine performance. Each type of installation has an impact on the operation of the fuel system and needs to be evaluated and approved.

3. DISCUSSION

a. Fuel Pressure and Fuel Quantity Indicator

(1) A fuel pressure indicator is required for pump-fed engines in accordance with § 23.1305(g). It is intended to monitor metered fuel pressure at the inlet to the injector and to advise the pilot of a fuel pressure deficiency. Many small airplanes with reciprocating, continuous-flow, fuel-injection engines are equipped with fuel pressure indicators that actually measure metered fuel pressure. Metered fuel pressure in a fuel-injection system also relates to fuel flow, and can provide a satisfactory method for displaying fuel flow. However, replacing the metered fuel pressure indicators with fuel flowmeters could cause an unsafe condition by failing to provide critical fuel pressure information to the pilot that is especially important during the takeoff phase of flight. Fuel flowmeters are not required powerplant instruments for reciprocating engines to meet airworthiness standards of Part 3 of the CAR or Part 23.

(2) Digital fuel flow computer systems have a fuel flow transducer that directly measures the amount of fuel being fed to the engine. The fuel flow transducer may be a small paddle wheel, an impeller, or spring-loaded movable vanes. Digital displays with a fuel computer also permit these instruments to display total fuel consumed, total fuel remaining, and time remaining at the present fuel flow rate for fuel management. Overall accuracy for fuel remaining and time remaining readings depends on the transducer processing unit and display. The largest possible error is the initial fuel supply, which is entered by the pilot at the start of each flight. Errors in the initial fuel supply may be caused by an uneven ramp, unusual loading, volume changes of the fuel due to temperature variations, malfunctions in the fuel system such as leaks, siphoning actions, collapsed bladders, and other factors. Consequently, total fuel remaining should be verified with the fuel quantity indicator. In accordance with § 23.1337(b)(1), fuel quantity indicators are required to be calibrated to read "zero" during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply. For this reason, fuel quantity indicators should be used as the primary fuel-remaining instruments. Fuel quantity indicators that are inaccurate should be periodically calibrated, repaired, or replaced, as necessary, to ensure reliable readings.

b. Fuel-Injection Systems

Fuel-injection systems have been designed for many types of reciprocating engines, and they vary in details of construction, arrangement, and operation. Only continuous-flow, fuel-injection systems for reciprocating engines will be discussed in either the speed-sensing pressure pump or constant-pressure pump categories.

(1) Fuel-Injection System with Integral Speed-Sensing Pressure Pump

(a) A fuel-injection system with an integral speed-sensing pressure pump delivers fuel at a pressure proportional to engine speed, and the pump is approved as part of the engine type design during the engine certification process. The fuel-injection system has fuel lift capability that enables the system to function with a negative inlet pressure within specific limits as indicated by the engine type data sheet. An emergency fuel pump is not required when the fuel injection pump is approved as part of the engine in accordance with § 23.991(b). The airframe manufacturers may provide an auxiliary fuel pump located upstream of the fuel-injector pump for priming the engine and suppressing fuel vapors. This auxiliary fuel pump can provide some fuel during emergency operations but may not sustain engine operation at full power in the event the engine-driven, fuel-injector pump fails; therefore, it is not considered an emergency fuel pump.

(b) If the fuel system in the airplane can meet the fuel flow requirements of § 23.955(c) at the minimum allowable inlet pressure limits without the need of an external pump, a fuel pressure indicator is not required. Nonetheless, some manufacturers have installed a fuel pressure indicator that senses metered fuel pressure at the fuel distribution valve. Since metered fuel pressure is related to fuel flow, it can provide a means for displaying fuel flow. A pressure indicator that is measuring metered fuel pressure may have the scale marked in terms of fuel pressure, fuel flow, or percentage of engine power. With these fuel flow markings, the indicator sometimes is referred to as an analog pressure-type flowmeter. If an analog pressure-type flowmeter is installed as part of the airplane manufacturer's type certificate, a replacement digital or analog fuel flowmeter/fuel totalizer is acceptable, provided the installation meets the applicable airworthiness requirements mentioned in the Acceptable Means of Compliance.

(2) Fuel-Injection System with Constant Pressure Pump

(a) A fuel-injection system with constant discharge pressure during normal flight-engine-revolutions usually requires that fuel be supplied at a positive pressure within specified limits to the fuel-injector inlet. To provide this inlet pressure, the engine-driven fuel pump and the emergency pump are usually installed by the airplane manufacturer. An emergency fuel pump is required by § 23.991(b), and this pump should meet the fuel flow rate of § 23.955; therefore, it will sustain engine operation if the engine-driven fuel pump fails.

(b) A fuel pressure indicator is required for pump-fed engines in accordance with § 23.1305(g) and is intended for monitoring unmetered fuel pressure at the inlet to the injector. The fuel pressure indicator provides a means for the pilot to determine if the fuel pressure is within safe limits for proper operation.

(c) Several airplanes have been approved with a fuel pressure indicator connected to the fuel distribution valve where the fuel flow is a function of metered fuel pressure to the discharge nozzle. Metered fuel pressure is related to fuel flow and also relates to engine power output. In some applications, metered fuel pressure has been found acceptable for monitoring fuel pressure and controlling engine performance. The scale on the pressure indicator is to be marked in fuel pressure; in addition, it may be marked in either fuel flow or percentage of engine power output. A fuel pressure indicator at the inlet to the injector provides a more positive means of monitoring the operation of the engine-driven fuel pump and the emergency fuel pump.

(d) An airplane that has both a separate unmetered fuel pressure indicator and an analog pressure-type flowmeter may have the analog pressure-type fuel flowmeter replaced with a digital fuel flowmeter/fuel totalizer. If only an analog pressure-type fuel flowmeter is installed that actually operates from metered fuel pressure, the analog pressure-type fuel flowmeter may not be replaced with a digital fuel flowmeter/fuel totalizer unless another fuel pressure indicator is installed to sense the fuel pressure at the fuel-injector inlet. Or, the analog pressure-type fuel flowmeter may be replaced with a digital fuel flowmeter/fuel totalizer if an equivalent level of safety for the airplane shows that replacing the fuel pressure indicator with a flowmeter will still meet the applicable airworthiness requirement. A finding of equivalent level of safety should substantiate that the instrumentation provided by the fuel flowmeter is satisfactory, reliable, and safe under all reasonably foreseeable operating conditions.

4. ACCEPTABLE MEANS OF COMPLIANCE

An acceptable method of compliance with the airworthiness standards for installation of fuel flowmeters in small airplanes with continuous-flow, fuel-injection system, reciprocating engine is described below.

a. FAA Approval of Technical Data/Installation. Installation of the fuel flowmeter/fuel totalizer may be approved through Type Certification (TC) or Supplemental Type Certification (STC) for either the airframe or the engine. FAA approval is obtained after the applicant shows that the fuel flowmeter/fuel totalizer will perform its intended functions and ensures that no unsafe features are incorporated. The need for certification approval for the engine will be determined for each particular installation. Certification approval for the engine is not required when the applicant provides FAA approved data that shows an alternate configuration that permits a digital flowmeter with specific instructions. An improper installation not only will jeopardize the safety of the present designs, but could also increase the probability of system failure. Installations should comply with the airworthiness regulations and with the manufacturer's installation criteria.

b. Airworthiness Considerations

(1) Fuel-Injection System with Integral Speed Sensing Pressure Pump

Installation of a digital or analog fuel flowmeter may replace the analog pressure-type flowmeter.

(2) Fuel-Injection System with a Constant Pressure Pump

Installation of a digital or analog fuel flowmeter may replace the analog pressure-type flowmeter, provided an unmetered fuel pressure indicator is installed or it has been determined that replacing the fuel pressure indicator with a fuel flowmeter constitutes an equivalent level of safety.

(3) General Considerations

Changes to the fuel systems should be evaluated for fuel flow rates, maximum allowable pressure drop, hot weather operations, vibration and loads on lines and fittings, fire protection, and powerplant instruments, including effects of glare and reflections on instruments in the pilot compartment. An engineering analysis should be made to ensure good engineering practices are incorporated in the design and that the installation is in accordance with airworthiness standards of the following §§ 23.773, 23.955, 23.961, 23.993, 23.1183, 23.1191, 23.1337 and 23.1529 of Part 23. The fire-resistant capability of fuel system components in the engine compartment should be evaluated. The extent and nature of ground and flight evaluations depend upon each particular installation.

c. Evaluation

Modification of the approved fuel system may have major effects; therefore, an evaluation should be conducted to substantiate continued compliance of the fuel system with airworthiness requirements. FAA approval is issued when all airworthiness requirements are met. The following items should be considered:

(1) Fuel flow transducer should measure the total fuel flow under all operating conditions with either the engine-driven or the emergency fuel pumps. Some fuel systems provide an alternate fuel flow path under different operating conditions; for this reason, the fuel flow transducer should be installed upstream of the alternate fuel flow path.

(2) Fuel flow transducer should be installed downstream of any bypasses or vent returns to the fuel system.

(3) Maximum fuel pressure drop across the fuel flow transducer (normal and blocked conditions) should be within manufacturer's specifications and airworthiness requirements. Fuel pressure drop may affect the minimum fuel injector inlet pressure. The minimum fuel injector fuel inlet pressure may require redefinition, and the instrument range markings on the fuel pressure indicator may need to be revised. An engine-driven pump and emergency or boost pump may require adjustment to a higher pressure to account for the added restriction of the transducer. The pumps should be tested to ascertain their capability to supply the required fuel flow rate at the higher pressure. Flight tests for turbocharged engines may be required to determine that the minimum fuel injector inlet pressure meets the engine type certificate data sheet at the maximum approved altitude.

d. Markings and Placards for Powerplant Instruments

AC 20-88A provides guidelines on markings of airplane powerplant instruments. Sections 23.1541, 23.1543 and 23.1549 of Part 23 provide the airworthiness requirements for instrument markings and placards. Either the required range marking or placards, or both, should be furnished with the safe operating limits. A placard should be located near the fuel flowmeter/fuel totalizer display with the following statement: "Original equipment fuel quantity indicator is the primary reading of fuel on board the airplane."

e. Airplane Flight Manual (AFM)

A flight manual supplement or supplemental AFM or placards, if appropriate, should be prepared by the applicant. The information should be presented for FAA approval in the following sections:

(1) Limitation section should include placard information and instrument markings.

(2) Normal procedure section should include information on the operation and function of the equipment. Included in this section should be information that the fuel totalizer does not sense the quantity of fuel in the tank and it should not be used as a fuel quantity indicator. The accuracy of total fuel remaining displayed on the fuel flowmeter/fuel totalizer is dependent upon the initial fuel supply programmed into the computer before the start of each flight. Uncertainties about initial fuel supply and total fuel remaining can be due to an uneven ramp, unusual loading, volume changes of the fuel due to temperature variations, malfunctions such as leaks, siphoning action, collapsed bladder, and other factors; therefore, the total fuel remaining should be verified with the fuel quantity indicator. Before flight, it is essential that the pilot determine that the fuel programmed into the computer is the same as the usable fuel on board the airplane.

(3) The emergency procedure section should include any system malfunction that may occur due to electrical power failure and the procedures for verifying proper operation after power outages.

(4) If the certification basis does not require an AFM with the airplane, the applicant may provide a supplemental AFM or provide the necessary information to the pilot by means of placards.

Amendment 23-7 and Subsequent

1. Digital (Alphanumeric) Instruments

See AC 23.1311-1A for guidance on this topic.

2. Torque Meter Markings

Markings on torque meters should be as follows:

a. The maximum safe operating torque should be indicated by a red radial.

b. The green arc should extend across the complete normal operating range.

c. Takeoff torque can be indicated by the word “Takeoff” or the letters “T.O.” arranged as a radial with an explanation of their significance in the AFM.

3. Warning Means Instead of Indicators

Warning means for § 23.1305: oil quantity measuring device, powerplant ice protection indicating means, fuel system anti-ice indicating means, thrust reverser indicating means, and propeller blade angle indicating means, can be acceptable as an equivalent level of safety.

4. Fuel Strainer or Filter Indicators

Acceptable means of compliance for fuel strainers or filter indicators for turbine-engine airplanes are as follows:

a. A fuel filter approved under 14 CFR Part 33, § 33.67, Amendment 33-6, installed within the engine upstream of the high-pressure engine-driven positive displacement pump or the fuel metering device will comply with the provisions of § 23.997 without an airframe supplied filter. The fuel filter should be capable of sustained operation while operating with water in the fuel as specified in §§ 23.991(c) or 33.67(b)(4). An engine-driven, low-pressure fuel pump may be installed upstream of the fuel filter. If an airframe-mounted filter is not installed, care should be taken to ensure there are no undrainable low spots between the fuel tank outlet and the inlet to the engine.

b. A fuel strainer approved under § 33.67, Amendment 33-6, would not require an indicator in the cockpit to indicate the occurrence of contamination before it reaches the capacity of the fuel strainer, as required by § 23.1305(c)(8). However, an indicator on the engine should be installed such that it can be readily inspected for operation prior to flight. Instructions for this inspection should be included in the Preflight Check Procedures in the AFM.

c. Turbine engine installations that do not have a fuel filter per § 33.67 should have an airframe mounted fuel strainer to comply with § 23.997. Also, an indicator for contamination before it reaches the capacity of the fuel strainer, as required by § 23.1305(c)(8), should be provided.

For reciprocating engines, the fuel strainer should comply with all the requirements of § 23.997.

23.1307 Miscellaneous equipment

No policy available as of June 30, 1994.

23.1309 Equipment, systems, and installations

Amendment 23-14 and Subsequent

The FAA has reviewed the Part 1 definition of the word “instrument,” and other data and has concluded as follows:

a. Where a light is sufficient, the instrument requirement should be changed to a warning means.

b. Where trend information is needed, the word “indicator” should be retained.

c. Where point information or steps in a sequence need to be shown, the words should be changed to “indicating means” (i.e., the functioning of the ice protection system).

See AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes, for additional guidance.

Amendment 23-41 and Subsequent

Lightning

See AC 20-136, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning, and RTCA DO-160D, Environmental Test Conditions and Test Procedures for Airborne Equipment, Section 22, for guidance on lightning certification of IFR airplanes. As part of the ongoing review of natural lightning by the SAE Committee AE4L and EUROCAE WG-31, the multiple burst testing was revised from the AC 20-136 requirement of 24 bursts of 20 pulses, with 10m to 50 microseconds between bursts, to 3 bursts of 20 pulses with 50 to 1,000 microseconds between bursts.

High Intensity Radiated Fields (HIRF)

Special conditions will still be required for critical systems for High Intensity Radiated Fields (HIRF), since the words “radio frequency energy” in this rule are not intended to include HIRF. RTCA DO-160D, Section 20, is applicable for bench level testing for HIRF.

INSTRUMENTS: INSTALLATION

23.1311 Electronic display instrument systems

Amendment 23-41 through Amendment 23-48

Attitude and Heading

For Part 23, there is not a specific requirement that instruments at each pilot station be independent unless two pilots are required by the airworthiness or operational rules. Therefore, both electronic attitude and heading instruments can utilize the same attitude and heading reference source. For a single Attitude Heading Reference System (AHRS), the Airplane Flight Manual should include equipment operating limitations to alert the pilot(s) that a failure of the AHRS could simultaneously affect both attitude and heading instruments. However, a single AHRS may not be acceptable if its affect on an autopilot system is a possible catastrophic failure caused by the AHRS, such as an unannunciated slowover (softover) failure.

Amendment 23-41 and Subsequent

See AC 23.1311-1A, Installation of Electronic Displays in Part 23 Airplanes, for further guidance.

Paragraph (e) in § 23.1311 gives definitions specific to this rule for "instruments" and "primary."

Electronic Flight Instrument System (EFIS) Cooling

Monitors for failures of EFIS cooling fans are not required if the reliability of the fans; the system redundancies; the reversionary features; annunciation of over-temperature and its response time; and the availability of other flight instrumentation provides an adequate level of safety without fan monitors. Each installation should be evaluated on a case-by-case basis as to the particular design features, the certification basis of the airplane, and the installation of compensating equipment. Flight instrument functions such as attitude and heading on the EFIS should continue to meet their applicable performance standards in their installed environment for a minimum of 90 minutes after in-flight loss of the EFIS cooling provisions. Regardless of the length of time, if performance is substandard due to loss of cooling, then the failure condition should be annunciated to the pilot.

Rate of Turn

A rate of turn instrument is required by § 91.205 unless there is a third attitude instrument. The third attitude instrument should be usable from both pilot positions.

Altitude

Digital-Only (alphanumeric) displays for barometric altitude should not be approved.

23.1321 Arrangement and visibility

Original Issue and Subsequent

When applying this rule to powerplant instruments in multiengine airplanes, ensure there is no confusion as to the engine/instrument relationship. For instance, powerplant instruments for the right engine in a twin-engine airplane may not be placed over, under, or to the left of the left-engine instruments.

Amendment 23-14 and Subsequent

For all installations, the evaluation should consider the different environmental conditions under which the airplane may be operated as defined by § 23.1559.

Basic "T"

This rule applied the Basic "T" to standardize flight instrument locations. This was not intended to require a "perfect T:"

a. Deviations within the limits of plus 10^{o}/minus 15^{o} can be approved by an equivalent level of safety finding based on satisfactory service experience and research of other airplanes.

b. Deviations beyond those in paragraph (a) of this section would require an equivalent level of safety finding that would include human factors substantiation with a complete installation evaluation considering (1) the total instrument arrangement and its alignment to the normal line of the pilot's vision, (2) cockpit view, (3) the integration of other functions within the instruments, and (4) the ease of controlling the instruments.

Also, for all installations, the FAA has always intended that § 23.1321(d) apply to **each pilot's** station for both type certification and for any operations for which the airplane is approved. Therefore, when an airplane is type certificated with the "basic T" instrumentation at only one pilot's station, that **airplane is limited to operations where only one pilot is required** in accordance with §§ 23.1525 and 23.1583(h).

23.1322 Warning, caution, and advisory lights

No policy available as of June 30, 1994.

23.1323 Airspeed indicating system

Original Issue and Subsequent

Part 135, Operating Requirements: Commuter and On-Demand Operations, requires that IFR airplanes have a heated pitot tube for each airspeed system. In consideration of a four-pound bird strike, the minimum distance between pitot tubes that can be accepted is 14 inches, measured in a straight line.

Amendment 23-34 and Subsequent

See AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes, for additional guidance.

23.1325 Static pressure system

Amendment 23-1 and Subsequent

Both VFR and IFR airplanes should meet the requirements of § 23.1325 in paragraph (b)(3) of this regulation because static vent icing can occur during both VFR and IFR conditions with hazardous consequences. The rule provides for either an anti-icing means or an alternate static source.

a. If installed, the alternate static source is not restricted to emergency conditions but may be used to monitor the primary static system.

b. We suggest marking the secondary static source with the word "Alternate."

c. This rule also requires a correction card in the cockpit if the altimeter changes by more than 50 feet on the alternate source. The correction card does not need to be in clear view of the pilot as long as it is available to a pilot seated in the flight position. Providing alternate static information in the Airplane Flight Manual does not comply with the regulation. The alternate static source is separate, and its correction card should provide correction data for the alternate source only.

d. The alternate static source is subject to all parts of § 23.1325, as is the primary static source.

See AC 20-124, Water Ingestion Testing for Turbine Powered Airplanes, for guidance on testing the airspeed and static systems for water ingestion susceptibility.

Amendment 23-34 and Subsequent

See AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes, for additional guidance.

23.1326 Pitot heat indication systems

No policy available as of June 30, 1994.

23.1327 Magnetic direction indicator

Original Issue and Subsequent

If the magnetic compass required by § 23.1303 is the only heading instrument, then it should meet the requirements of this section. With an approved secondary system such as a directional gyro, and with an appropriate placard to dictate which electrical devices should be switched off when reading the magnetic compass, per § 23.1547, equivalent safety pursuant to Part 21, § 21.21(b)(1) may be shown.

Regarding magnetic direction indicators: heading information is considered an essential flight instrument function because its loss could result in reduced capability of the flight crew to cope with adverse operating conditions, especially for IFR flights. The indicator specified in this rule was intended to be a magnetic compass (non-stabilized). The requirement for a magnetic direction indicator existed before remote indicating compasses were available. If a magnetic stabilized direction indicator is installed as an additional instrument, the magnetic non-stabilized direction indicator (magnetic compass) is still required as the primary source of magnetic direction.

a. A magnetic direction indicator with remote magnetic sensor can be approved under § 21.21 of Part 21 if it can be substantiated that it provides a level of safety equal to that provided by the magnetic compass required by § 23.1303(c). The reliability of the system should consider the effects of loss of the airplane's electrical system, the performance of the equipment under environmental conditions that may be encountered by the airplane, the integrity of the interface wiring, and the reliability of the components.

b. For a magnetically stabilized direction indicator approved under an equivalent level of safety finding, the system should be powered from a source that is independent of a single electrical generating system. This other source should be installed so that it is operative without manual selection after total failure of a single electrical generating system. Dual independent stabilized indicator installations with split electrical bus systems may also be approved on multiengine airplanes under an equivalent level of safety finding. The airplane's battery is not considered an acceptable source unless the state of charge of the battery is displayed to the pilot.

c. The following installation requirements of §§ 23.1327 and 23.1547 are also directly related to approval of either type of magnetic indicator:

(1) The accuracy is not excessively affected by the airplane's vibration or magnetic fields.

(2) Deviations of more than 10° in level flight are not permissible, unless a magnetic stabilized direction indicator which does not have a deviation in level flight greater than 10° on any heading, or a gyroscopic direction indicator, is installed.

(3) A placard should show the calibration of the instruments in level flight with the engine(s) operating and whether the calibration was made with the radio receivers on or off.

(4) If deviations of more than 10° caused by operation of electrical equipment are approved, the placard should state which electrical loads or combination of loads would cause deviations of more than 10°.

23.1329 Automatic pilot system

Original Issue and Subsequent

A single malfunction may not result in a hardover signal in more than one axis. When the result of any single malfunction is shown not to be hazardous (no hardover signals) (slowover signals are acceptable if they are determined to be easily controllable without requiring exceptional skill or strength), then multiple axes being affected is acceptable.

Alterations that increase engine horsepower (and either engine horsepower or major changes in exterior cowlings and surfaces, etc.) in Part 23 airplanes should consider the compatibility of the autopilot system with the increased horsepower, since the malfunction and performance tests of the autopilot are conducted with a defined amount of engine power. Generally, an increase in engine horsepower beyond 10 percent may adversely affect the autopilot system malfunctions, performance, controllability, and longitudinal stability characteristics. Therefore, flight testing may be necessary to verify that the original approval of the autopilot system is still valid.

a. The results of malfunction testing determine which flight condition is most critical. The effects of autopilot runaways are more pronounced at aft center of gravity (c.g.). Furthermore, the phase of flight with the largest contribution to adverse conditions varies with airplane model.

b. Airplane longitudinal stability is a factor in autopilot system malfunctions. Generally, there is an inverse relationship between engine horsepower and longitudinal stability. Although the turbine engine installations replacing reciprocating engines may be flat rated, the turbine is capable of producing increased horsepower at higher temperatures and altitudes, which could reduce longitudinal stability. Therefore, autopilot performance, especially the pitch axis hardover malfunction, should be evaluated for acceptability. This policy is also applicable to power increases on airplanes with reciprocating engines, either engine replacement or engine modifications that add a turbocharger.

c. Performance and controllability evaluations should be considered, including the configuration of most forward c.g. and minimum autopilot authority. This configuration is used to demonstrate that the airplane can be safely controlled by the autopilot when the control surface hinge moment is the highest and the autopilot controllability is at its lowest during corresponding longitudinal trim and airspeed changes.

To show compliance with Part 23, § 23.1329, applicable to autopilot system installations in small airplanes, the following is acceptable.

1. RELATED REGULATIONS AND DOCUMENTS

a. Regulations

These acceptable means of compliance refer to certain provisions of Part 23. They may be used in showing compliance with the corresponding provisions of the former Civil Air Regulations (CAR) in the case of airplanes to which the CAR regulations are applicable. For convenience, the Part 3 section reference is shown in parenthesis following the Part 23 section reference:

§ 23.143 (3.106)	Controllability and Maneuverability, General.
§ 23.253	High speed characteristics.
§ 23.395 (3.231)	Control system loads.
§ 23.397 (3.212)	Limit control forces and torques.
§ 23.689 (3.345)	Cable systems.
§ 23.777 (3.384)	Cockpit controls.
§ 23.779 (3.384)	Motion and effect of cockpit controls.
§ 23.1301 (3.651 and 3.652)	Function and installation.
§ 23.1309	Equipment, systems, and installations.
§ 23.1321 (3.661 and 3.662)	Arrangement and visibility.
§ 23.1322	Warning, caution, and advisory lights.
§ 23.1329 (3.667)	Automatic pilot system.
§ 23.1351 (3.681)	Electrical Systems and Equipment, General.
§ 23.1381 (3.696 and 3.697)	Instrument lights.
§ 23.1431 (3.721)	Electronic equipment.
§ 23.1555 (3.762, 3.763, and 3.765)	Control markings.
§ 23.1581 (3.77)	Airplane Flight Manual and Approved Manual Material, General.
§ 23.1583 (3.778)	Operating limitations.
§ 23.1585 (3.779)	Operating procedures.

b. Advisory Circulars

AC 21-16D	Radio Technical Commission for Aeronautics (RTCA) Document DO-160D.
AC 23.1309-1C	Equipment, Systems, and Installations in Part 23 Airplanes.

c. Technical Standard Order

TSO-C9c	Automatic Pilots.

d. Industry Documents

RTCA/DO-160D	Environmental Test Conditions and Test Procedures for Airborne Equipment.
RTCA/DO-178B	Software Considerations in Airborne Systems and Equipment Certification.

2. BACKGROUND

AC 23.1329-1, Automatic Pilot Systems Approval, which sets forth an acceptable means for showing compliance with the autopilot installation requirements, was issued December 23, 1965. Although AC 23.1329-1 was inadvertently canceled in 1977, criteria essentially equivalent to that contained therein continued to be used to show compliance with the applicable autopilot installation requirements. The airworthiness regulations prescribe the requirements for autopilot installation approval. The following criteria have been applied and found reasonable and acceptable in previous type certification programs for complying with specific sections related to these approvals:

a. Compliance with the regulations necessitated the conversion of the force exerted by one pilot to overpower an engaged autopilot into measurable terms when either an autopilot quick disconnect or interrupt switch was **not** provided. The values in the table under § 23.143 are maximums. There may be circumstances where a maximum force less than 75 pounds is required for safety. For example, if a pilot is trying to overpower a nose-up malfunction during climb and reduce power at the same time, a maximum safe force may be less than 75 pounds. Consequently, these forces, as measured at the pilot's controls, were equated to the following temporary and prolonged forces:

(1) The maximum temporary force to overpower the autopilot has not been allowed to exceed 30 pounds in roll (force applied at the rim of the wheel), 50 pounds in pitch, and 150 pounds in yaw. These forces are applicable only to initially overpowering the autopilot system.

(2) The maximum prolonged force to overpower the autopilot should not exceed 5 pounds in roll, 10 pounds in pitch, and 20 pounds in yaw.

b. A reasonable period of time has been established for pilot recognition between the time a malfunction is induced into the autopilot system and the beginning of pilot corrective action following hands-off or unrestrained operation. The following time delays have been acceptable:

(1) A 3-second delay following pilot recognition of an autopilot system malfunction, through a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable failure warning system in the climb, cruise, and descent flight regimes.

(2) A 1-second delay following pilot recognition of an autopilot system malfunction, through a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable warning system, in maneuvering and approach flight regimes.

3. ACCEPTABLE MEANS OF COMPLIANCE

The following procedure, in accordance with the forces and times above, is acceptable as a means of showing that an autopilot system installation is in compliance with the airworthiness rules:

a. Cockpit Controls

Evaluation of cockpit controls should include the following:

(1) The location of autopilot system controls should be readily accessible to the pilot, or both pilots, if a minimum of two pilots is required.

(2) Annunciators should conform to the proper color as specified in § 23.1322.

(3) A determination that the controls are usable under bright sunlight and night lighting conditions (§ 23.1381).

(4) **Either** a quick disconnect or interrupt switch for the autopilot system are located on the side of the control wheel opposite the throttle(s) and are red in color. A disconnect switch stops all movement of the autopilot system. An interrupt switch momentarily interrupts all movement of the autopilot system.

(5) A determination that any automatic disconnects of the autopilot is adequately annunciated by an aural warning. If warning lights are utilized to supplement the aural warning, they should meet the requirements of § 23.1322. Use of a visual warning as the sole means of annunciating automatic disconnects is not considered acceptable.

(6) Motion and effect of autopilot cockpit controls should conform with the requirements of §§ 23.1329(c) and 23.779.

b. Malfunction Evaluations

(1) Malfunction evaluation flights should be conducted with the airplane loaded at the most critical weight or the most critical c.g./weight combination. Maximum untrimmed fuel imbalance should be considered during the evaluation. If autothrottles are installed, they should be operating, and autopilot servo torque should be set to the upper tolerance limit. The simulated malfunctions should be induced at various airspeeds and altitudes throughout the airplane's airspeed and altitude envelopes. These envelopes should include the maximum operating altitude for turbocharged or high altitude airplanes, or be within 10 percent of the service ceiling for normally aspirated airplanes, and when the airplane is stabilized in the normal operational attitudes. Vertical gyro mechanical failures should not be considered. The simulated failures and subsequent corrective actions are not acceptable if they result in any of the following:

(i) Loads that exceed the substantiated structural design limit loads.

(ii) Acceleration that is outside the 0 to 2g envelope. The positive "g" limitation may be increased up to the positive design limit maneuvering load factor if it has been previously determined analytically that neither the simulated failure nor subsequent corrective action would result in loads beyond the design limit loads of the airplane.

(iii) Speeds in excess of V_{NE} or for airplanes with an established V_{MO}/M_{MO}, a speed midway between V_{MO}/M_{MO} and the lesser of V_D/M_D, or the speed demonstrated under § 23.253.

(iv) Deviations from the flight path including bank angle in excess of 60° or pitch attitude in excess of $\pm$ 30° deviation from the attitude at which the malfunction was introduced.

(v) A hazardous dynamic condition.

(2) Normal Flight Malfunctions

The airplane's performance should be evaluated when the effect caused by the most critical single failure condition that can be expected to occur to the system and can be detected by the pilot is induced into the autopilot system. Hidden or latent failures, in combination with detectable failures, should be considered when determining the most critical failure condition. Normal flight includes climb, cruise, and descent flight regimes with the airplane properly trimmed in all axes. Airplane configurations (combinations of gear and flaps), speeds, and attitudes should be evaluated for unsafe conditions. The more critical of the following simulated malfunctions are the following:

(i) A simulated malfunction about any axis equivalent to the cumulative effect of any failure or combination of hidden failures, including manual-electric or automatic trim, if installed.

(ii) The combined signals about all affected axes, if multiple axis failures can result from the malfunction of any single component. Since Amendment 3-2 to Part 3 of the CAR, effective August 12, 1957, the requirements are that an autopilot system should be designed so that a single malfunction will not produce a hardover signal in more than one control axis (reference §§ 3.667(e) and 23.1329(e)).

Note: A 3-second delay following pilot recognition of an autopilot system malfunction, as indicated in Item 2b(1), should be applied for normal flight malfunction evaluations.

(3) Maneuvering and Approach Malfunction

Maneuvering flight tests should include turns with the malfunction induced at the maximum bank angle for normal operation, up to and including the autopilot authority limits. Airplane configurations (combinations of gear and flaps), airspeeds, and altitudes should be evaluated to determine if unsafe conditions exist. Simulated malfunctions described for normal flight malfunctions as indicated in Items 3b(2)(i) and (ii) (titled, “Normal Flight Malfunctions”) are applicable for introduction during maneuvering flight malfunction evaluation. The resultant accelerations, loads, and speeds should be within limits described for normal flight malfunctions. Malfunctions introduced during coupled approaches should not place the airplane in a hazardous attitude or an attitude that would prevent the pilot from conducting a missed approach or safe landing. Altitude losses resulting from the simulated malfunctions are to be measured accurately and presented in the Limitations Section of the Airplane Flight Manual (AFM) or approved manual material. In maneuvering and approach flight regimes, the pilot should recognize an autopilot system malfunction within 1-second. This recognition should occur as the result of a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable warning system that is applied.

Note: Accurate measurement of altitude loss, due to an autopilot malfunction during an instrument landing approach, is essential. This altitude loss during a critical phase of flight provides the basis for establishing the minimum approach altitude during autopilot coupled approaches. The loss should be determined by measuring from the altitude at which the malfunction is induced to the lowest altitude observed during the recovery maneuver, unless instrumentation is available to measure the vertical deviation from the intended glide path to the lowest point in the recovery maneuver. In this section, Appendix 1 contains a method of measurement for approach altitude loss. Altitude losses due to malfunctions in other flight regimes, though less critical, may be determined by measuring the deviation from the flight path in a manner similar to that used for the glide slope.

(4) Alternate Means of Compliance for Autopilots Incorporating Electronic Monitors/Limiting Devices

Listed below are alternate means of compliance. These alternate means cite considerations for evaluating both monitors and limiting devices when functioning of such devices is necessary to prevent the airplane from exceeding the malfunction limits identified in paragraph 3b(1) of this AC.

(i) Alternate Means No. 1

(A) Monitor/Limiter Inhibited

With the monitor/limiter inhibited, autopilot malfunction flight testing may **not** cause any of the following:

(1) Roll to exceed 80°.

(2) Pitch to exceed +45°, -35°.

(3) Accelerations outside the 0g to 2.5g envelope.

(4) Airspeed exceeding V_{NE} or for an airplane having an established V_{MO}/M_{MO}, a speed not greater than a speed midway between V_{MO}/M_{MO} and the lesser of V_D/M_D or the speed demonstrated under § 23.253.

(B) Reliability and Prerequisite Criteria

(1) A fault analysis should show that the failure effect of a monitor failure, combined with an autopilot malfunction, is less than major; and

(2) Pre-engagement check of the monitor is mandatory. No credit is allowed for a pilot-activated pre-engagement check unless there is a lockout device or system.

(ii) Alternate Means No. 2

(A) Monitor/Limiter Inhibited

With the monitor/limiter inhibited, autopilot malfunction flight testing may **not** cause any of the following:

(1) Roll to exceed 80°.

(2) Pitch to exceed +45°, -35°.

(3) Accelerations outside the -0.2g to 2.5g envelope.

(4) Airspeed exceeding V_{NE} or for an airplane having an established V_{MO}/M_{MO}, a speed not greater than a speed midway between V_{MO}/M_{MO} and the lesser of V_D/M_D or the speed demonstrated under § 23.253.

(B) Reliability and Prerequisite Criteria

(1) An acceptable fault analysis showing that the failure effect of a combined monitor failure and an autopilot malfunction is less than hazardous. In addition, the failure effect of failure of a lockout device to inhibit autopilot engagement, as identified in Item (3) below, is less than major ;

(2) Pre-engagement check of the monitor is mandatory with either a manual or automatic activation means; and

(3) Autopilot engagement is inhibited until pre-engagement check is successfully completed.

(iii) Alternate Means No. 3

(A) Flight tests with monitors inhibited are not required.

(B) Reliability and prerequisite Criteria

(1) An acceptable fault analysis showing that the failure effect of a combined monitor failure and autopilot be less than catastrophic. In addition, failure of a lockout device/system to inhibit autopilot engagement, as identified in Item (3) below, is less than hazardous;

(2) Pre-engagement check of the monitor is mandatory with either a manual or automatic activation means;

(3) Autopilot engagement inhibited until the pre-engagement check is successfully completed; and

(4) Autopilot authority not greater than necessary to satisfactorily control the airplane.

c. Recovery of Flight Control

Evaluate the ability to recover flight control from the engaged autopilot system either by manual use of a quick disconnect or by physically overpowering the system.

d. Performance Flights

Performance evaluation tests should be conducted with the airplane loaded to its most adverse c.g. and weight condition. Autopilot performance with the servo torque values at the lowest production torque tolerance limit should be used to demonstrate safe controllability and stability. Flight tests are necessary to ensure the autopilot system performs its intended function, including all modes of operation presented for approval (reference § 23.1301).

e. Single-Engine Approach

For multiengine airplanes, an engine failure during a normal instrument landing system (ILS) approach should not cause a lateral deviation of the airplane from the flight path at a rate greater than 3° per second or produce hazardous attitudes. This rate should be measured and averaged over a 5-second period. If approval is sought for ILS approaches initiated with one engine inoperative, the autopilot should be capable of conducting the approach.

f. Airplane Flight Manual (AFM) Information

The following information should be placed in the AFM, the Pilot's Operating Handbook (POH), or presented to the pilot in the form of placards:

(1) In the Operating Limitations Section, the airspeed limitations, maximum altitude for operation if different from the maximum certificated altitude of the airplane, category of ILS approaches for which approval is granted, minimum approach height, and any other applicable limitations.

(2) In the Operating Procedures Section, the normal operating information, including navigation and glide slope intercept recommendations. For those autopilot systems which incorporate either monitors or limiter devices, the pre-engagement procedures and the means of indicating that the pre-engagement has been successfully completed.

(3) In the Emergency Operation Procedures Section

(i) A statement of the altitude loss in the cruise, climb, and descent configurations; and maneuvering flight conditions, due to possible malfunctioning of the autopilot system.

(ii) A statement of the altitude loss due to malfunctions while in the approach configuration. If engine inoperative approach is approved, the altitude loss should be included.

(iii) Any other procedure related to emergency procedures associated with either the autopilot or associated systems. (See Figure 1.)

Altitude Loss

1. Malfunction inducement point.
2. Malfunction recognition by pilot.
3. Initiation of manual recovery action by pilot.
4. Altitude loss with no instrumentation.
5. Altitude loss with instrumentation.

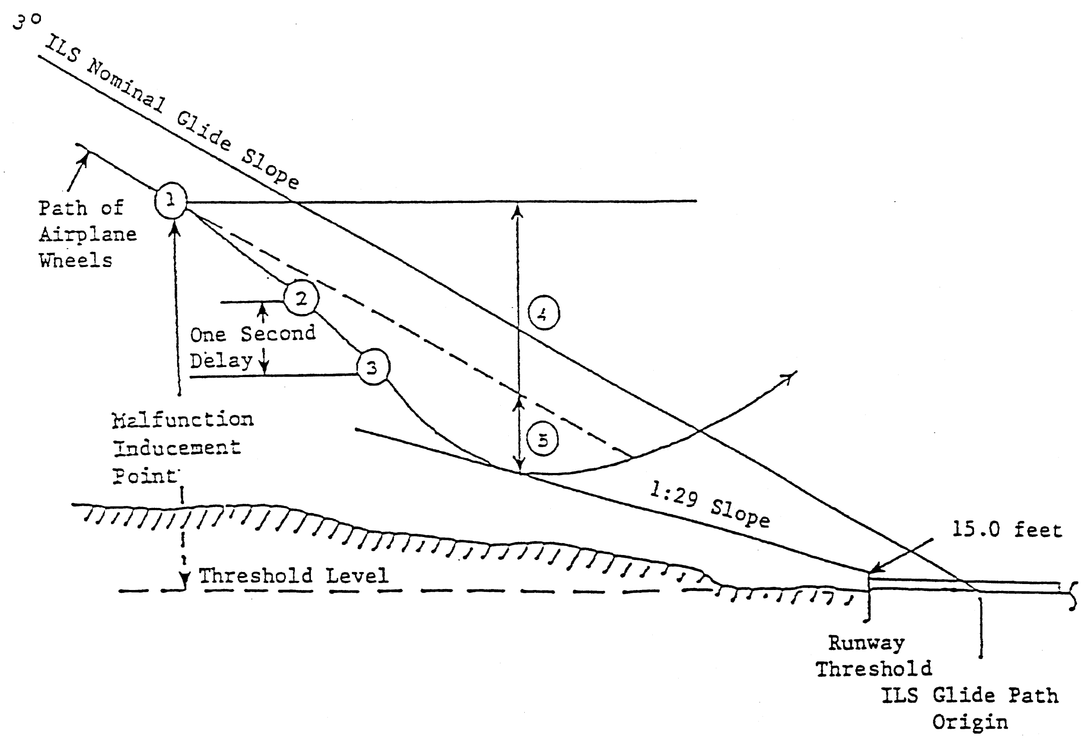

FIGURE 1. ACCEPTABLE METHOD FOR DETERMINING ALTITUDE LOSS IN APPROACH

FIGURE 1—CONTINUATION

Malfunction Evaluations. The airplane should be established on the ILS glide slope and localizer in the configuration(s) with the approach speed(s) specified by the applicant for approach. Simulated automatic flight control system malfunctions should be induced at critical points along the ILS taking into consideration all design variations and their limits in automatic flight control system sensitivity and authority. The malfunctions should be induced in each axis. While the pilots may know the purpose of the flight, they should not be informed when a malfunction is to be or has been applied except through a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable failure warning system. After a failure, recovery should be initiated 1 second after the pilot recognizes the failure.

a. A 3° glide slope should be used for these tests in order to determine the malfunction effects to be expected in service.

b. For use during a coupled ILS approach, the automatic control system should not fail in such a way that it causes the airplane wheels to descend below a limit line lying below the glide slope, sloping upward at 29:l from a point 15 feet above the runway threshold. With the airplane established on the glide slope in approach configuration, at approach speed, the most critical malfunction is induced at a test altitude referenced to the runway threshold. Measure the altitude loss between the test altitude and the lowest point of the manual recovery, unless instrumentation is available to measure the vertical deviation from the intended glide path to the lowest point in the recovery maneuver. The altitude loss and the known distance to the threshold from the lowest recovery altitude are compared to the limit line. The lowest test altitude from which malfunction and manual recovery can be completed, without the airplane wheels descending below the limit line, is considered the minimum height for use of the automatic flight control system.

c. Recovery from all malfunctions should be demonstrated either by overpowering or by manual use of an emergency quick disconnect device after the appropriate delay. The pilot should be able to return the airplane to its normal flight altitude under full manual control without exceeding the defined limits.

23.1331 Instruments using a power source

Original Issue and Subsequent

Paragraph (a) in § 23.1331 applies only to gyroscopic instruments, but paragraph (b) in this section applies to any instrument that depends on external power or external energy for proper operation.

The requirement for two independent power sources in paragraph (b)(1) in § 23.1331 applies to either vacuum or electrically driven gyroscopic instruments.

Electrical Systems

When complying with paragraph (b) in this section, a single battery required for starting is acceptable if the electrical system is capable of continuous normal operation without external excitation or stability, and there is no probable failure of the battery that will adversely affect the electrical system once it is operating. However, the airplane battery cannot be accepted toward showing compliance to the power source requirements of §§ 23.1331 and 23.1351 unless the state of charge of the battery is displayed to the pilot.

A single electrical bus is unacceptable for a multiengine airplane.

The multiengine requirement is for two **independent** power sources. Therefore, an installation with a single primary power source for all flight instruments and a manually operated backup is not acceptable.

a. This system could conceivably fail in such a way that all the flight instruments could be simultaneously damaged or disabled (i.e., loss of voltage regulation). This would not be remedied by switching to the backup power source.

b. Also, an electrical system with a primary power source that employed a backup source with common circuitry or components is not truly independent.

Standby Vacuum Systems

The intended function of a standby vacuum system is to provide a second vacuum source for the gyroscopic instruments after a failure of the primary vacuum system. The standby system should either supply sufficient vacuum to maintain the accuracy and reliability of the gyroscopic instruments throughout the phases of flight, or there should be limitations on operation in the Airplane Flight Manual (AFM). When operating on the standby system, the pilot should predicate operations on other certified systems (partial panel) and use the gyroscopic instruments as an aid, provided the pilot determines these instruments give acceptable information. Also, the pilot should not manipulate the throttle, other than for normal flight, in an attempt to control vacuum pressure within the limitations.

Since a second vacuum system is not required for single-engine airplanes, the standby installation would be for non-required equipment per this rule. In addition, § 21.21(b)(2) requires there be no feature that results in an unsafe condition. To comply with these requirements, it should be shown that neither operation nor failure of the standby vacuum system will interfere with the normal operation of the primary system or result in any unsafe condition. The pilot should also be kept apprised of when the standby system is in operation either by manual source selection or by red visual annunciation (§ 23.1322) if an automatic switching system is installed. To ensure that no unsafe condition will result, the standby system should be flight evaluated in each unique airplane installation. In addition, operating information, emergency procedures, and limitations should be available in an AFM Supplement, a Supplemental AFM, or placards, as appropriate. This information should meet the requirements of §§ 23.1583 and 23.1585 of this Part, and it should emphasize that the standby vacuum system is for emergency use only and should not be utilized for dispatch purposes.

Amendment 23-43 and Subsequent

Independent Power Sources

This amendment adds the requirement for independent power sources for required instruments for single-engine as well as multiengine airplanes. This was considered appropriate due to the number of single-engine airplane accidents that were attributed to the loss of power to required flight instruments. Also, the reference to "gyroscopic" was removed to include both gyroscopic and non-gyroscopic instruments since non-gyroscopic flight instruments are in use.

a. Instruments that provide required flight information and use an external power source are now required to have two independent power sources. This requirement has the same intent for single-engine airplanes as for multiengine airplanes: to functionally isolate flight instruments such that any failure of one power source or instrument will not cause the complete loss of a required flight instrument function. Thus, in the case of failure of a heading instrument, that failure may not result in the loss of the proper supply of energy to the attitude indicator powered by the same source, and loss of a single power supply may not cause loss of any required instrument function.

b. Ship's batteries used in normal operations are acceptable as backup power sources only if their state of the charge can be reliably verified to the pilot.

c. This regulation is not intended to apply to circuit protection devices, which are to be considered in §§ 23.1351 and 23.1357.

d. <u>These changes are meant to apply to those instruments that rely on a power source and provide required flight information.</u> Such instruments are those that provide information for direct control of flight that are required by the kinds of operation for which the airplane has been approved. Therefore, instruments in airplanes limited to VFR operations that are not required for VFR would not have to comply with the requirements of § 23.1331. Exemptions would not be necessary or appropriate.

23.1335 Flight director systems

No policy available as of June 30, 1994.

23.1337 Powerplant instruments installation

Original Issue and Subsequent

No specific criteria have been established for the minimum orifice size for fuel and oil lines. We believe that .020 inches for fuel lines and .060 inches for oil lines can be accepted (per Air Force Systems Command Manual 80-1, Part C, Chapter 5, paragraphs 3.1.1.3.7 and 3.1.2.3.3).

See AC 23-16, Powerplant Guide for Certification of Part 23 Airplanes, § 23.959, for unusable fuel test procedures for guidance on § 23.1337(b)(1).

Changes to total fuel quantity by incorporation of a fuel tank filler connection (§ 23.973) outboard of the existing connection will require changing the fuel quantity indicator to indicate the new quantity of fuel. The new indicator should meet the accuracy as specified in TSO-C55, Fuel and Oil Quality Instruments (For Reciprocating Engine Aircraft), or MIL-G-9798.

Amendment 23-18 and Subsequent

See AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes, for guidance on fuel quantity indicators and auxiliary tanks.

ELECTRICAL SYSTEMS AND EQUIPMENT

23.1351 General

Original Issue

This rule does not allow a failure or malfunction of any electrical power source to impair the ability of any other source to supply essential circuits.

Amendment 23-7 and Subsequent

This amendment allows one exception to the original rule. This exception would allow loss of an alternator that is dependent on a battery for initial excitation or stabilization when that battery has failed. This exception was adopted under the premise that the advantages of having a battery connected for initial excitation or stabilization for alternators needing it outweighed the consequences of that battery failing. This exception is only applicable to alternator installations that need a battery. Loss of an alternator due to battery failure was considered of no greater consequence than the intrinsic failure of the alternator itself. In the case of single-engine airplanes, loss of the battery and alternator would result in the loss of the electrical system, which would be no worse than other single failures (i.e., shorts to ground, conductor failure, etc.) that would also result in loss of the electrical system.

Wire meeting MIL-W-5086 has been removed from the listing of approved wire in AC 43.13-1B due to its flammability characteristics, corrosive vapors, and toxic gases of PVC insulation. See AC 43.13-1B, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair, Section 3, for allowable wire in airplane manufacture and alteration.

23.1353 Storage battery design and installation

Original Issue and Subsequent

See AC 43.13-1B, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair, Section 8, for battery installation guidance. Replacement batteries would require Parts Manufacturer Approval (PMA), unless exempted under the provisions of Part 21, § 21.303(b), whether the replacements are lead-acid or nickel-cadmium.

23.1357 Circuit protective devices

Original Issue and Subsequent

This rule allows only one essential circuit on one circuit protective device. The intent of the rule is met for installations that integrate position and anticollision lights on one wire when no single failure can cause the loss of any of the following:

(a) More than all anticollision lights.

(b) More than all position lights.

(c) More than one position light and the anticollision light adjacent to it.

The requirement in § 23.1357(e) applies to fuses for all circuits, not just essential circuits. Although spare fuses for non-essential systems and equipment do not have to be resettable in flight.

The phrase "essential to safe operation," as used in Part 135, Appendix A, paragraph 64, and the phrase "essential to flight safety" in § 23.1357(b) have the same meaning as "essential to safety in flight" in § 23.1357(d) and "essential to flight safety" in § 23.1357(b). All of these phrases are descriptive of equipment installed in order to comply with the airworthiness or operational requirements. The FAA recognizes that some required circuit protection devices are associated with circuits that can have no significant impact on safety in flight. Therefore, the responsible Aircraft Certification Office (ACO), in conjunction with the applicant, should identify which circuits and circuit protection devices are essential to safety in flight. The identified circuits should comply with § 23.1357(d) regarding the pilot's ability to reset them in flight.

The intent of § 23.1357(b) is that, in the case of an essential load, its individual circuit should be the **only** load on an individual circuit protection device. This intent was explicitly stated in Amendment 23-20.

For Part 23 applications, the definitions of a switch and a circuit breaker are as follows: a switch is a device for opening and closing or for changing the connection of a circuit; a circuit breaker is a device designed to open and close a circuit by non-automatic means and to open the circuit automatically at a predetermined overload of current, without injury to itself when properly applied within its rating. Consequently, circuit breakers used for operational functions are not acceptable in that they are not performing their intended function, which is protection against overloads. Circuit breakers, even those suitable for frequent operation, should not be used as a switch to perform procedural functions.

A combination switch/circuit breaker is a device which can perform both as a switch for opening and closing a circuit as well as a circuit breaker, automatically opening the circuit at a predetermined overload current.

23.1359 Electrical system fire protection

No policy available as of June 30, 1994.

23.1361 Master switch arrangement

No policy available as of June 30, 1994.

23.1365 Electric cables and equipment

Original Issue and Subsequent

Section 23.1365 requires that each cable that would overheat in a circuit overload or malfunction be at least flame resistant and not emit dangerous quantities of toxic fumes. The compliance methods for the flame resistance requirement are in AC 23-2, Flammability Tests. To aid in meeting the toxic fume requirement, the FAA has removed MIL-W-5086 wire from the listing of approved wires in AC 43.13-1B, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair.

Amendment 23-14 and Subsequent

The flame resistance and toxic fume requirements are applicable to equipment associated with the cable as well as the cable itself.

23.1367 Switches

Original Issue and Subsequent

Switches are required to be labeled as to operation and the circuit controlled. A switch that operates by a push once for ON and once for OFF should be labeled "PUSH OFF/ON."

Switches are also required to be accessible to the flight crew. The intent of this rule is that those switches that are installed in the cockpit should be accessible to a flight crew member **if** manual operation is necessary for safety of flight.

LIGHTS

23.1381 Instrument lights

No policy available as of June 30, 1994.

23.1383 Taxi and landing lights

No policy available as of June 30, 1994.

23.1385 Position light system installation

Original Issue and Subsequent

Guidance on light measurements can be found in AC 20-74, Aircraft Position and Anticollision Light Measurements. Additional guidance on position lights can be found in AC 20-30B, Aircraft Position Light and Anticollision Light Installation.

Guidance on flame resistance can be found in AC 23-2, Flammability Tests.

The intent of the rule in § 23.1357 is met for installations that integrate position and anticollision lights on one wire when no single failure can cause the loss of any of the following:

(a) More than all anticollision lights.

(b) More than all position lights.

(c) More than one position light and the anticollision light adjacent to it.

Position lights are not required for airplanes limited to Day VFR operation (placarded for VFR Day). If approved for Night VFR or IFR, then position lights are required per §§ 23.1385 through 23.1395. They should be listed on the kinds of operation equipment list (§ 23.1559(b)) and included in the Limitations Section of the Airplane Flight Manual (§ 23.1583(h)).

23.1387 Position light system dihedral angles

No policy available as of June 30, 1994.

23.1389 Position light distribution and intensities

No policy available as of June 30, 1994.

23.1391 Minimum intensities in the horizontal plane of position lights

No policy available as of June 30, 1994.

23.1393 Minimum intensities in any vertical plane of position lights

No policy available as of June 30, 1994.

23.1395 Maximum intensities in overlapping beams of position lights

No policy available as of June 30, 1994.

23.1397 Color specifications

Original Issue and Subsequent

See AC 20-74, Aircraft Position and Anticollision Light Measurements, for guidance on color measurements.

23.1399 Riding light

No policy available as of June 30, 1994.

23.1401 Anticollision light system

Original Issue and Subsequent

If certification for night operation is requested, an anticollision light system, per this section, is required.

See AC 20-74, Aircraft Position and Anticollision Light Measurements, for guidance on anticollision light measurements.

The flash rate of supplemental lights does not have to be applied to the anticollision light flash rate, but these lights should be checked to verify there is no unsafe condition associated with their use.

Amendment 23-11 and Subsequent

There is no restriction on mixing aviation red and aviation white anticollision lights on the same airplane. Likewise, there is no restriction on the ratio of red to white provided that the light displayed in any one direction is **either** aviation red **or** aviation white.

Some white supplementary lights have been presented for certification as anticollision lights. The visible limit of such lights may converge at some point forward and aft of the airplane such that from this point to the airplane neither light is visible. The maximum allowable distance to such convergence is 1,200 feet.

The regulations (§ 23.1397) require that aviation white's "X" coordinate be no less than 0.300 and no greater than 0.540 (International Civil Aviation Organization (ICAO) Annex 8 requirement). Xenon flash tubes can exceed the "X" limit for some energy levels (20 to 40 joule range). For the function of an anticollision light, an occasional excursion beyond the 0.300 limit would not adversely affect safety or the performance of the intended function. We have been advised by the National Bureau of Standards (NBS) that the measurement accuracy of the "X" value of chromaticity coordinates includes an error tolerance of plus or minus 0.008. It was not envisioned that filtering would be required on Xenon flash tubes to meet the aviation white limits since the color can be effectively limited by capacitor circuitry to control the energy level of individual flashes. The maximum joules per flash should be such that the 0.300 will not be exceeded more than 68 percent of the time and 0.292 will not be exceeded 99.7 percent of the time (3 sigma), which includes the measurement error tolerance suggested by NBS.

SAFETY EQUIPMENT

23.1411 General

No policy available as of June 30, 1994.

23.1413 Safety Belts and Harnesses [Removed]

See guidance for § 23.785.

23.1415 Ditching equipment

No policy available as of June 30, 1994.

23.1416 Pneumatic de-icer boot system

No policy available as of June 30, 1994.

23.1419 Ice protection

Original Issue and Subsequent

For additional information relating to Part 23, § 23.1419, see AC 23.1419-2A, Certification of Part 23 Airplanes for Flight In Icing Conditions.

Icing terms "Light," "Moderate," and "Severe" are found in operational rules for flight planning and pilot reporting purposes. They are not part of the airworthiness rules, which refer to continuous maximum and intermittent maximum icing, per Appendix C of Part 25.

Amendment 23-14 and Subsequent

It is not required that an applicant demonstrate performance per Part 23 with ice shapes or under natural icing conditions. It is required that the manufacturer demonstrate satisfactory handling qualities, stall characteristics, etc., with ice shapes on unprotected surfaces. If these characteristics are found to be unsatisfactory, the manufacturer will be required to modify the icing package or restrict the center of gravity to a range where satisfactory handling qualities can be demonstrated.

To certificate a single-engine airplane for flight in icing conditions, Part 21, § 21.101 would require the same criteria to be applied as in VFR, IFR, Day and Night flight, which is to keep the airplane in the air and flying even if performance is compromised somewhat. This may require redundancy in ice protection system components to minimize hazards to the airplane in the event of a probable malfunction or failure.

There is no requirement or allowance for making adjustments in the icing certification program for the frequency of encountering icing conditions. A probability of one is to be used for encountering discrete environmental conditions such as instrument meteorological conditions. Icing conditions are environmental conditions, and an encounter frequency of less than one for compliance with §§ 23.1093 and 23.1419 is not appropriate.

Amendment 23-43 and Subsequent

This amendment defines "capable of operating safely" as having performance, controllability, maneuverability, and stability **not less** than that required by Subpart B of Part 23. Therefore, the applicant has to meet the Subpart B requirements with ice shapes on the airplane.

MISCELLANEOUS EQUIPMENT

23.1431 Electronic equipment

Original Issue and Subsequent

Mercury cell battery packs for use in Emergency Locator Transmitters (ELT) should be manufactured by controlled processes. Service experience has shown that ELT mercury cell battery packs fabricated by individuals without a controlled process can result in the following:

a. Degradation of the cell seal causing leaks and a shorter shelf life.

b. Creation of internal shorts.

c. Internal corrosion.

d. Creation of highly explosive mercury fulminate.

The possibility of adverse interaction between communication and navigation equipment should be evaluated. Momentary indicator deflection or flicker is acceptable. However, loss of a required function due to interaction of assignable frequencies in the National Airspace System is not acceptable.

Interim guidance for TCAS I installations is given in AC 20-TCAS, Airworthiness Approval and Operational Use of Traffic Alert and Collision Avoidance System (TCAS I) (in draft).

Guidance for TCAS II installations is given in AC 20-131A, Airworthiness and Operational Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders.

Automatic NAVAID selection tuning (Auto-tune) of Very High Frequency Omnirange Station/Distance Measuring Equipment (VOR/DME) for flight management or multisensor navigation systems is designed to enhance the navigation accuracy for enroute flight. Under certain conditions, and depending on the particular implementation, the auto-tune function can cause a hazard if auto-tune remains operative during VOR and ILS operations. In this case, automatic selection of a NAVAID different than that wanted by the flight crew is a possibility. Visual cues indicating the auto-tune is still active may be quite subtle and may go unnoticed during a high workload period. If the auto-tune NAVAID is reasonably in line with the projected track, the anomaly can go undetected—causing the airplane to fly an erroneous track based on the auto-tune NAVAID. This may occur either when steering manually or when the flight guidance system has been engaged. System installations that employ auto-tune should be mechanized in a manner that addresses these safety issues. An acceptable method of auto-tune implementation is to automatically inhibit the auto-tune feature when a navigation function other than the one utilizing auto-tune has been selected for display on the Horizontal Situation Indicator/Electronic Horizontal Situation Indicator (HSI/EHSI).

Moving Map Displays (MMD) used for primary command guidance during IFR flight should be evaluated with the particular navigation receiver (GPS, LORAN-C, etc.) to be used. It should also be restricted to use with that particular type of receiver on that particular airplane. If a separate command or deviation indicator is used to certify the system for IFR use, the MMD should be placarded “For Reference Only” and used only if it can be shown that failure of the MMD would not fail the navigation system.

An MMD to be used for and placarded for “VFR Only” guidance would need verification that it performs its intended function when used with a particular navigation receiver. It could then be used on any other airplane with the same type navigation receiver.

23.1435 Hydraulic systems

No policy available as of June 30, 1994.

23.1437 Accessories for multiengine airplanes

No policy available as of June 30, 1994.

23.1438 Pressurization and pneumatic systems

No policy available as of June 30, 1994.

23.1441 Oxygen equipment and supply

Amendment 23-9 and Subsequent

Plastic lines (nylon, polyvinyl chloride (PVC) and Teflon) are **not** acceptable for use in continuously pressurized, non-portable oxygen systems.

Plastic lines can be used in non-portable oxygen systems that are pressurized only when cabin decompression occurs with the following precautions:

a. Swaged metal type end fittings should be used to prevent leakage from cold flow.

b. Lines should be protected from abrasion by use of a reinforcing sleeve of fabric braid.

c. Lines should be routed away from areas where they might be subjected to elevated temperatures, electrical arcing (relays and switches), and flammable fluids.

d. Refer to AC 43.13-2A, Acceptable Methods, Techniques, and Practices—Aircraft Alterations, Chapter 6, for additional guidance material.

Part 23 is unique in that it allows oxygen system requirements to be met with portable systems. For those portable systems, information should be provided to the flight crew in the form of limitations stating which portable system is approved, which components constitute the system, and any operating limitations.

Part 23 airplanes may be certified with or without an oxygen system. The necessity for supplemental oxygen is a function of the operational altitude not the airplane design. Therefore, the requirements for when supplemental oxygen is required can be found in General Operating and Flight Rules. If installed, the system should meet the following Part 23 airworthiness requirements: (a) §§ 23.1441 through 23.1449 (and § 23.1450 if chemical oxygen generators are used), and (b) it may be a basic part of the airplane or a portable system. Section 23.1525 requires the airplane operational limits be established in accordance with the installed equipment or lack thereof. If an airplane is delivered without an oxygen system, its Airplane Flight Manual should have a limitation or there should be a placard prohibiting flight above 14,000 feet mean sea level (MSL).

23.1443 Minimum mass flow of supplemental oxygen

Original Issue and Subsequent

When there is full compliance to this regulation, there is no need to consider the probability of a pressurization failure or to require an immediate descent in altitude in the event of a failure. Compliance should include the consideration of a rapid/explosive decompression to ambient pressure with a pilot recognition and reaction time of 17 seconds to initiate a descent.

(a) The airplane may be altitude-limited to meet this requirement, or

(b) The applicant may provide an equivalent level of safety finding.

23.1445 Oxygen distribution system

Amendment 23-43 and Subsequent

The guidance in this AC for § 23.1441, Amendment 23-9 and subsequent, for plastic lines is applicable to this regulation.

23.1447 Equipment standards for oxygen dispensing units

Amendment 23-30 and Subsequent

This amendment allows the use of nasal cannulas for operation up to an altitude of 18,000 feet Mean Sea Level (MSL). These are simple devices and the FAA has not developed a design standard for them.

Section 23.1447(e) requires that oxygen masks be automatically presented to each occupant before the cabin pressure exceeds 15,000 feet for airplanes certificated for operation above 30,000 feet MSL. So, just before the cabin pressure altitude exceeds 15,000 feet, the oxygen mask should fall down automatically and present itself to a 95th percentile human occupant at mouth level within the visual periphery. All the occupant should have to do is pull the mask from the hanging position, don the mask, and start breathing.

23.1449 Means for determining use of oxygen

No policy available as of June 30, 1994.

23.1450 Chemical oxygen generators

No policy available as of June 30, 1994.

23.1451 Fire protection for oxygen equipment

No policy available as of June 30, 1994.

23.1453 Protection of oxygen equipment from rupture

No policy available as of June 30, 1994.

23.1457 Cockpit voice recorders

No policy available as of June 30, 1994.

23.1459 Flight recorders

No policy available as of June 30, 1994.

23.1461 Equipment containing high energy rotors

Amendment 23-20 and Subsequent

This regulation requires that equipment containing high energy rotors meet § 23.1461(b), (c) or (d). An acceptable means of compliance to § 23.1461 is given in AC 20-128A, Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure.